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HYDROXYLAMMONIUM NITRATE COMPATIBILITY TESTS WITH VARIOUS MATERIALS - A LIQUID PROPELLANT STUDY -

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U.S. ARMY LABORATORY COMMAND

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The compatibility of hydroxylammonium nitrate ("HAN"), a key ingredient of liquid gun propellants, with 48 different materials of construction was tested in short-term immersion tests in constant temperature baths with observation and measurement of gas evolution. Test temperatures were 298 K and 338 K (25°C and 65°C). Test duration was 30 days. Materials tested included metals, plastics, ceramics, coatings, and lubricants. At the end of the test, the gas spaces above the solutions were analyzed for gas composition. Evolution of nitrous oxide and nitrogen was evidence of incipient decomposition in the propellant. The off-loaded HAN solutions were analyzed for leached metals. Based on the rate of gas evolution, weight loss of the specimens, discoloration of the liquid, and amount of metals leached, several materials were identified as being incompatible with 60% HAN solutions.

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Chapter 1

INTRODUCTION

1.1 GENERAL INFORMATION

This is the final report on a contract that was awarded to Rocket Research Company (RRC), in the Aerospace Division of the Defense Systems Group of Olin Corporation, by the United States Army Ballistic Research Laboratory (BRL), Aberdeen Proving Grounds as the result of a competitive procurement in response to solicitation DAAD05-89-R-5453. The BRL Contracting Officer's Representative was Mr. Ronald A. Sasse'.

The research program involved the testing of candidate materials of construction for compatibility with the key ingredient of liquid gun propellants, namely concentrated aqueous solutions of hydroxylammonium nitrate, $NH_3OH^+ NO_3^-$ (HAN). Materials included metals, alloys, plastics, and lubricants.

Rocket Research Company has been actively involved in compatibility testing of materials of construction with rocket propellants such as hydrazinium nitrate solutions in water and hydrazine. Hydrazine is a hydronitrogen compound similar to hydroxylamine. Hydrazinium nitrate is an acidic salt as is hydroxylammonium nitrate. The RRC propellant compatibility test effort has continued for over twenty years and storability data are now available on several nitrate propellant blends in contact with various materials of construction. The tankage system of a liquid propellant gun is similar to tankage systems for energetic monopropellants for rocket propulsion. The extreme temperatures encountered in the liquid propellant gun breech are similar to temperatures encountered in rocket engines. It is from this related experience background with liquid rocket monopropellants that RRC has approached the liquid gun propellant materials compatibility question.

1.2 OBJECTIVE

The objective of this final report is to provide all information necessary to document the progress made by the contractor in comparison to the goals established in the work plan and the contract statement of work. It is a further objective of this report to assemble the vast amount of data generated during the contract in an easily accessible "user-friendly" format. The format should be such that the user will quickly obtain information about the acceptability or incompatibility of a candidate material of construction.

1.3 SCOPE OF WORK

The purpose of this contract was to determine the effect of various materials of construction, including metals, alloys, plastics, and greases on liquid gun propellants (LGP). One hundred tests had to be performed on one ingredient of the LGP-1845 or LGP-1846 propellant called hydroxylammonium nitrate, NH_3OHNO_3 (HAN). These 100 tests were performed on 48 Government-furnished (GFE) materials and two controls (HAN without any additive) at two different temperatures, 298 K (25°C) and 338 K (65°C). Pressure rise during the 30-day tests was monitored daily as an indication of compatibility. Post-test samples were examined for signs of corrosion and some of the off-loaded propellant was analyzed for leached metals. The gas space above the samples was analyzed for chemical composition of the gases formed. This gas composition information can be useful to interpret the mechanism of incompatibility.

1.4 PROBLEM STATEMENT

There are two concerns about the compatibility of materials of construction with liquid gun propellant ingredients. The first is the effect of the corrosive medium on the material, causing possible loss of structural integrity. The second is the effect of contaminants leached from the material of construction on the storage stability of the propellant. The test program conducted here addressed both concerns.

Chapter 2

TECHNICAL APPROACH

Forty-eight (48) Government-furnished (GFE) materials and two blanks (hydroxylammonium nitrate solution only, no material specimen inserted) were tested at two different temperatures for periods of 30 days and the rate of gas evolution was measured. At the end of the test, if sufficient gas had evolved, the nature of the evolved gas was determined by gas analysis. The propellant off-loaded from the test tube was analyzed for leached metals (if the material was a metallic material) and the specimens were examined for weight change and changes in appearance.

2.1 LIQUID GUN PROPELLANTS

Liquid gun propellants currently under consideration consist of concentrated aqueous solutions of hydroxylammonium nitrate and triethanolammonium nitrate. The corrosive properties of this solution make it necessary to conduct careful materials compatibility evaluations. The solutions are ionic (though not fully ionized due to the high salt concentration), mildly acidic, contain both oxidizing and reducing species, and would therefore be expected to be reactive with a large number of materials.

Composition of Liquid Gun Propellants. For actual applications, two slightly different liquid gun propellants are being considered: BRL-1845 and BRL-1846. These propellants have been historically called BRL-1845 and BRL-1846 but are now also called Liquid Gun Propellant LGP-1845 and LGP-1846. In the context of the work reported here, the two designations (BRL and LGP) are used interchangeably.

Nominal compositions of LGP-1845 and LGP-1846 were given in a physical properties report published by BRL (Reference [1]).

LGP-1845 consists nominally of

63.23 wt.-% hydroxylammonium nitrate
19.96 wt.-% triethanolammonium nitrate
16.81 wt.-% water

When expressed in terms of molarity instead of mass percent, LGP-1845 has the following nominal composition:

9.62 M hydroxylammonium nitrate
1.38 M triethanolammonium nitrate
13.64 M water

LGP-1846 consists typically of

60.79% hydroxylammonium nitrate
19.19% triethanolammonium nitrate
20.02% water

or, in terms of molarity of the solution:

9.09 M hydroxylammonium nitrate
1.30 M triethanolammonium nitrate
15.93 M water

There is currently no existing military specification for these propellants. Until such a specification is issued, deviations of +/- 0.5% by weight from the nominal compositions have been considered acceptable for testing and contracting procurement purposes. The maximum amount of free acid allowed is recommended at 0.1%.

The materials compatibility of these two LGP propellants is essentially identical. The contract statement of work required the contractor to use aqueous HAN solutions containing from 57 to 63% by weight HAN. The nominal HAN concentration used in this study was 60.8% HAN which is equivalent to a 12.2 molar solution and identical to the nominal HAN content in LGP-1846.

Similar propellants previously developed by the U. S. Navy, such as the NOS-series, also included hydroxylammonium nitrate, but only few previous materials compatibility investigations are published on those propellants (Reference [2]).

Effects of Metal Ion Contamination on Thermal Stability of Liquid Gun Propellants. For practical applications of liquid gun propellants it is imperative that the propellants be storable under field conditions (-40 to +160°F). Both storage stability and thermal stability of HAN solutions and liquid gun propellants are adversely affected by the presence of transition metal ions. Transition metal ions are readily leached from the surface of incompatible materials in contact with the propellant. RRC has observed this phenomenon on numerous occasions with hydrazine and hydrazinium salt solutions which act similar to aqueous hydroxylammonium nitrate solutions.

Lack of storage stability would slowly degrade the liquid gun propellant to a point where the impetus no longer meets the required performance criteria. A reported laboratory test in which a 3-month exposure of LGP-1846 to a piece of copper foil resulted in reduction of HAN concentration from 60.33% to 49.12% is described in Reference [3]. Excessive gas evolution accompanying such obvious incompatibility might burst storage containers overpressurization. Insoluble corrosion products or evaporation residues formed as the result of decomposition and corrosive attack might clog injector flow passages or foul spark plugs in the ignition system.

Lack of thermal stability might also result in premature ignition of liquid g propellants in the injection passage prior to injection into the breech or before the liquid charge injection cycle in a regenerative gun is complete. Such instability could also make the propellants more susceptible to adiabatic compression initiation.

In an effort to guarantee storage and thermal stability, two common safety measures are being taken:

1. The propellant ingredients and all liquid gun propellants are procured to a specification which limits the amount of tolerable contamination in the starting product. Acceptance tests will be conducted to verify compliance of loaded liquid gun propellants with the procurement specification.

2. As a second precaution, all materials coming in contact with liquid gun propellants are carefully screened in a materials compatibility test program to assure that no transition metal ions (or any other metal ions) are leached from the materials of construction during storage or operation of the liquid propellant gun.

It is for the second reason that the just completed testing program was proposed and a contract was awarded. In addition to metals leached from inorganic materials, other species can be leached from nonmetallic materials that would interfere with proper operation of the gun. Organic tar or resin residues on the sliding surfaces of the regenerative gun piston might cause the piston to jam or particulates on the injection valve seat might cause the valve to leak. However, no analysis for leached organics was conducted under the program described here.

During the development of liquid gun propellants it became apparent to various authors that the presence of transition metal ions adversely affected the thermal stability and storability of the mixtures (References [4], [5], [6] and [7]).

Initially these tests had been conducted with LGP-1845 and LGP-1846 which consists of hydroxylammonium nitrate (HAN), triethanolammonium nitrate (TEAN), and water. Copper, iron, and nickel ions were found to be the most deleterious contaminants and it was assumed that other transition metal ions might have similar effects. In general, and again in agreement with observations made at Olin Rocket Research with hydrazine propellants, elements with incomplete d- shells in their electronic structure are catalytically most active. Zinc or cadmium, although they are also transition group elements, have completely filled d-shells and are less active. Conversely, cadmium has a stabilizing effect for hydrazine solutions.

Of the two salt ingredients in LGP-1845 and LGP-1846 propellant, the HAN was found to be the propellant component that was predominantly responsible for adverse reactions with metals. Therefore, additional studies were carried out with HAN solutions at other organizations to isolate the effect and avoid any interference by TEAN (References [8,9] and [10]). There do not seem to be any plans to study materials compatibility with TEAN/water system in an effort to isolate the cause of materials incompatibility with LGP and in order to parallel the HAN/water studies done here. It is not anticipated that much could be learned from such a study. More could be learned by studying HAN/water first as was done here. The effect of the presence of TEAN on the overall corrosion phenomena has not yet been studied in detail.

Reactions of copper and iron ions in HAN solutions were studied in detail and it was shown that the reaction of Fe^{3+} is electrocatalytic while the reaction of Cu^{2+} is not (Reference [11]). The reason for the strong catalytic activity of iron is the ease with which it changes its state of oxidation between the trivalent and the bivalent state. In HAN solutions, Fe^{3+} is reduced by hydroxylammonium ion to Fe^{2+} and the Fe^{2+} is re-oxidized to the trivalent state by the nitrate ion. If sufficient iron leaches from an incompatible material of construction that was inadvertently built into the storage tank, it is quite possible that the propellant will be expended after several years of storage. Even after a short time, the performance of the propellant would be degraded to a point where it would not longer meet the specification. Gas evolved during this period may rupture the tank. The time to rupture of sealed glass vials has been used as a test method to measure compatibility of LGPs with materials of construction (Reference [12]).

Copper Cu^{2+} ion, on the other hand, although it does not undergo the multiple valence change as easily as iron, catalyzes the production of nitric oxide NO during propellant decomposition. In the presence of air, NO converts to NO_2 which reacts with the propellant and greatly enhances thermal decomposition, thus rendering the propellant less stable.

2.2 SELECTION OF PROPELLANT SOLUTIONS

2.2.1 Preparation of HAN Solutions

Testing was to be performed in solutions containing from 57 to 63% hydroxylammonium nitrate with a nominal concentration of 60.8% (12.2 molar). This is similar to the HAN concentration in LGP-1846, with the TEAN portion replaced by additional water.

Hydroxylammonium nitrate was commercially available as 24% aqueous solution (4.8 molar) from Southwestern Analytical Chemicals in Austin, TX. The 24% solution is easily concentrated in a Rotavapor under partial vacuum in a water bath not exceeding 45°C (Reference [13]). The 24% HAN solution is shipped as a *Corrosive Liquid N.O.S.* - UN1760 per CFR 49. The more concentrated 60% (12.1 molar) solution is neither cap-sensitive nor is it positive in the card gap test at zero cards (Reference [14]). Experimental quantities of 85% HAN solutions have been shipped under an *Oxidizer (N. O. S.)* UN1479 49CFR 173.153(B)(1) designation (Reference [15]).

Filling at least 100 flasks with 40 mL of HAN solution during the current contract required at least 4 L of the 60% solution. Reserve solution was also prepared for those tests that might have to be terminated after 1 day or 7 days, requiring a substitute material to be placed in test with fresh solution.

2.2.1.1 HAN Assay Analysis Methods

If one assumes the HAN solutions are pure, then the easiest way to quickly measure the approximate HAN concentration is by density or refractive index. Also an accurate determination of HAN assay can be made by acidimetric titration with KOH or NaOH and visual or potentiometric end point indication. Initially, HAN assay titrations were performed at U. S. Army laboratories using KOH solutions in ethanol as the titrant (Reference [16]). The assay analysis of HAN solutions is substantially easier than the analysis of LGP-1845 or LGP-1846 since only two instead of three ingredients are involved. For the analysis of ternary LGP propellants, other bases have to be used as titrants (Reference [17]).

Olin Chemicals, a major proposed future producer of HAN solutions, uses an automatic titrator to analyze not only for HAN assay, but also for free nitric acid in the finished product (Reference [18]), but unfortunately such an instrument was not available for HAN assay determinations during the current program and titration with visual end point indication with an acid-base indicator was used instead. A previous BRL contractor (References [19] and [20]) had used an acidimetric titration with 1-N sodium hydroxide and thymolphthalein indicator. This method has the disadvantage that it will not recognize HAN solutions that are deficient in free nitric acid and have excess free amine.

Therefore, an alternate method for titrimetric HAN assay was recommended by the U. S. Army BRL Contracting Officer's Representative after start of the contract (Reference [21]). This method adds a known amount of nitric acid to the sample to be analyzed prior to its titration. The nitric acid is then subtracted when the results are calculated. This method has the advantage that also small deviations of nitric acid deficiency can be recognized. This method recommends the addition of a known amount (1 to 4 mL) of 0.25 M to 0.30 M nitric acid to a solution of 28 grams of LGP or HAN solution in 40 mL distilled water, mixing, and titrating with 0.2 M to 0.3 M NaOH solution.

2.2.1.2 HAN Analysis for Trace Metals

It is imperative to verify that the batch of HAN solution prepared at the beginning of the contract is free from contaminant metal ions that could jeopardize the success of the entire test series. Therefore, the procured 24% solution as well as the concentrated 60% solution has been analyzed for trace contamination of heavy metals. The main objective of the analysis was to analyze for iron, copper, nickel, and chromium to verify the absence of these metals in concentrations greater than 5 ppm. The analysis methods are described in more detail in Par. 2.7.

In the absence of a military specification (MIL SPEC) for the procurement of HAN or LGP-1846, RRC used the following product specification in the procurement of 24% HAN solutions, as do other contractors:

Hydroxylammonium nitrate content	24% minimum, 25% maximum
Sum of all heavy metals (Fe, Cu, Cr, Ni etc.)	5 ppm maximum
pH	2.5 to 3.0
Total other contaminants (e.g. ammonium nitrate)	1.0% maximum
Free nitric acid	0.1% maximum
color	colorless, clear

The supplier was asked to supply a batch analysis with the shipment of the chemical. The supplier stated that their product has typically the following properties:

Hydroxylammonium nitrate content	24±1 %
pH	3 to 4
Free nitric acid (stabilizer)	less than 0.01 molar
Aluminum	less than 0.2 ppm
Sulfate	less than 10 ppm
Barium	less than 0.1 ppm
Chloride	less than 10 ppm
Iron	less than 0.2 ppm
Sum of calcium and magnesium	less than 10 ppm
Ash	less than 10 ppm
Color	colorless, clear

Our results of HAN analysis are given in Paragraph 3.1.1.

2.3 SELECTION OF MATERIALS TO BE TESTED

The selection of materials to be tested was not the responsibility of the contractor under the current contract. The 48 different materials tested were Government Furnished Equipment (GFE) samples. The 48 materials included metals, coatings, ceramics, plastics, and lubricants. The statistical distribution of the types of materials tested is illustrated in Figure 2.1.

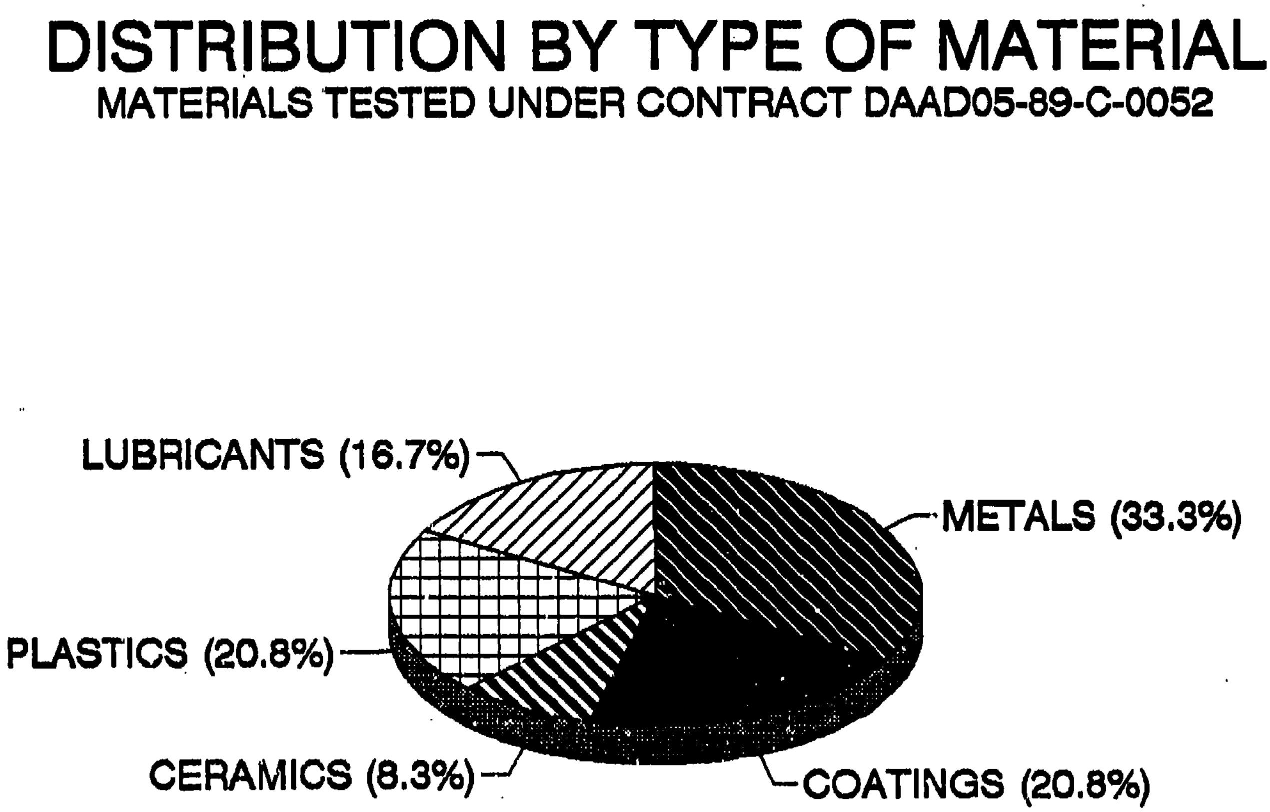

Figure 2.1: Distribution by Type of Materials

The main system components expected to be in long-term contact with the propellant are the tank, the propellant lines, the shutoff valve, the shuttling piston in a regenerative liquid propellant gun, and the injector nozzles. In addition, propellant management devices (bladders, diaphragms, pistons) separate the pressurant gas and the propellant. At the beginning of the contract, emphasis was on materials that would be in contact with mixed propellants. During a later contract period, other materials were added that may be used in chemical plants where HAN is manufactured and mixed with TEAN.

As was indicated in the proposal (Reference [22]), it was anticipated that sufficient material for at least three test coupons of each material would be provided by the contracting agency: one for the 298 K (25°C) test, one for the 338 K (65°C) test, and one to keep as a control coupon for before-and-after side-by-side photography should the appearance change as the result of the exposure. Unfortunately, insufficient material was available such that before-and-after side-by-side photographs could not be taken on those samples where corrosive attack was visible.

GFE materials were received in three different shipments over the course of four months and were used "as received" (except for cutting them to uniform size). No additional cleaning was done with any of the samples.

It is important to maintain traceability as to the origin of the material for the sake of reproducibility. For instance, it may be desirable to conduct future testing on similar or even identical materials (e.g., using HAN/TEAN/H_2O blends instead of HAN solutions) and make comparisons. The results might differ slightly if materials from different vendors or batch numbers were used. It is suggested to procure a supply of identical material now for future tests, and making the vendor names and batch numbers part of the test record. Many vendors make process changes, but maintain the same brand name or trademark on that product. Most vendors are quite generous in supplying free no-cost evaluation samples, but such samples are rarely documented by manufacturing date and batch number.

2.4 EXPERIMENTAL METHODS

2.4.1 Description of Test Apparatus

A schematic of the test apparatus and the constant temperature bath is shown in Figure 2.2. The apparatus consisted of a 50-mL borosilicate glass ampule to which was attached a mercury-filled U-gauge for measuring the pressure of the evolved gases. Gas evolution was taken as a sign of materials incompatibility and the rate of gas evolution was a measure of the degree of incompatibility. It was of interest to determine the nature of the evolved gases to make deductions about the probable cause of decomposition and possible effects of products on the materials exposed to the vapor phase alone.

HAN COMPATIBILITY TEST APPARATUS

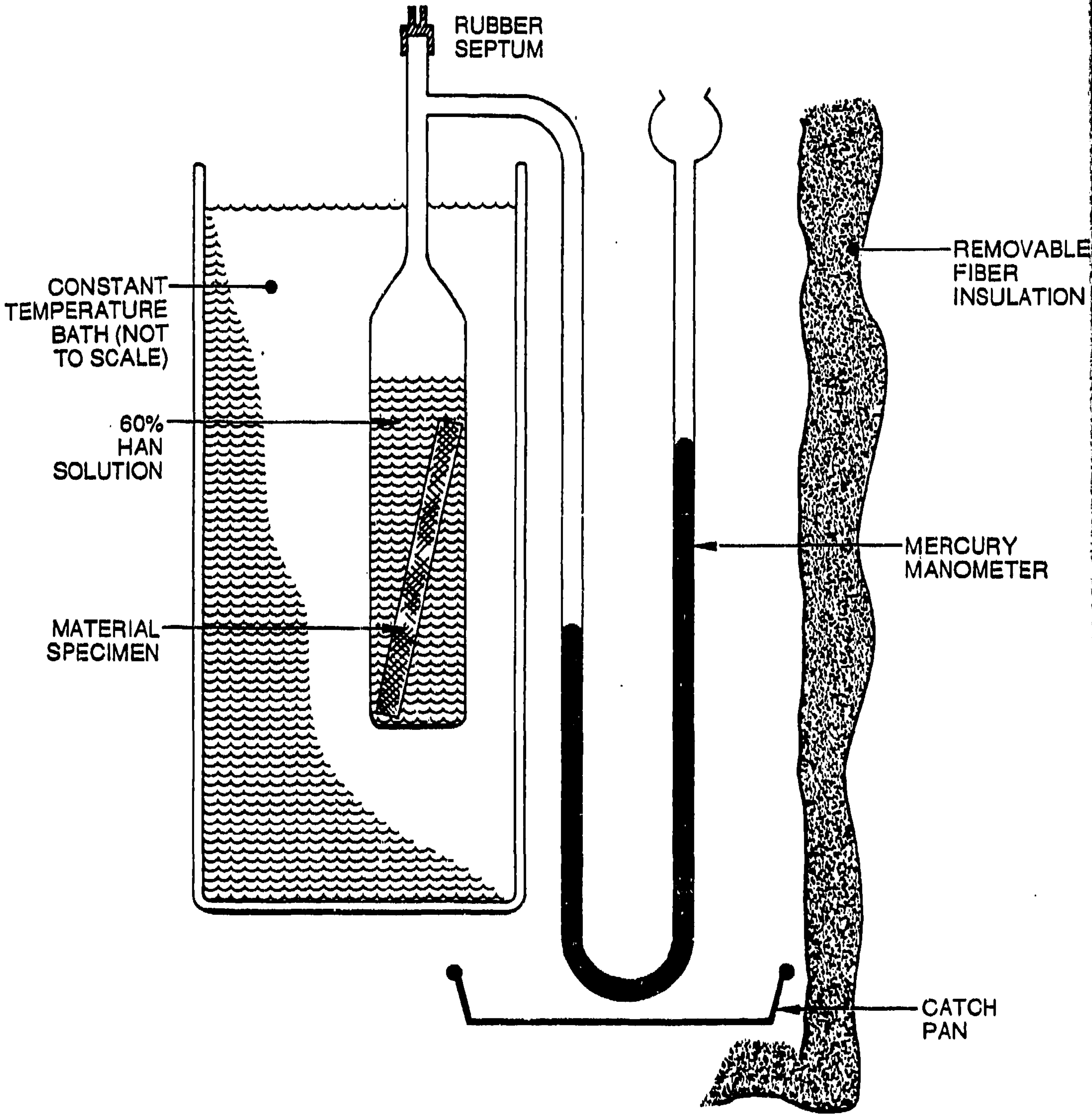

Figure 2.2: HAN Compatibility Test Apparatus, Schematic

Borosilicate glass (Pyrex) was chosen for the compatibility flasks. In this regard, hundreds of compatibility tests at RRC have been carried out using Pyrex flasks and the rate of gas evolution in the control flasks is always very low. The control flasks will be from the same batch of ampules as those used for the materials compatibility tests.

The ampules came from the supplier in a cleaned condition. The ampules were similar to ampules used for medicinal injection fluids. The ampules were taken from the sealed box, inspected visually for cleanliness, and used without additional cleaning, just prior to inserting the materials sample. The connection to the U-gauge was then made with a fused glass seal using standard glass blowing techniques. The U-tube gauges were pre-assembled and cleaned with laboratory detergent (e.g., Alconox), rinsed with distilled water, and dried prior to attaching them to the ampules.

In most cases, the ampules were attached to the U-gauge with the sample already in place inside the ampule. In a few cases, the apparatus could be assembled first and the skinny sample could be slid through the narrow neck of the assembled apparatus. Also, all oil and grease samples could be injected after the apparatus was already completely assembled. Extreme care had to be taken to prevent scorching the sample while the glass blowing was in progress. This was a comparatively simple operation since RRC's standard compatibility apparatus has to be sealed with a glass blowing torch while the sample and the propellant is already in place. Having high-energy propellant in immediate vicinity of a glass blowing torch and red hot molten glass requires additional safety precautions which were not necessary in this program.

Following the glass blowing, the assembled apparatus was evacuated and tested for leaks with a Tesla coil in a darkened room. Any pinholes in the fused glass joints could thus be identified before the apparatus was filled with propellant. The evacuation also served to remove any condensation in the flask caused by the preceding glass blowing operation. The two openings (the rubber septum port and the open end of the manometer) were covered with temporary rubber septums and the ampules were then stored in ambient air or in the glove box under argon until they were ready to be filled with HAN solutions. The remaining steps were carried out in an argon-filled glove box to eliminate ambient air (see Par. 2.4.2 Selection of Test Atmosphere).

The design of the ampule/manometer combination used at RRC was modified from that used by a previous BRL contractor such that the septum port was now coaxial with the ampule and the syringe needle would now reach clear to the bottom of the ampule without having to snake around bends in the apparatus. This design is superior because it avoids accidental smearing of liquid on the walls in the vapor space of the apparatus.

The liquid was injected into the assembled apparatus (already containing the materials specimens) through a capillary syringe needle from a graduated syringe. This allowed accurate dispensing of exactly 40 mL of the HAN solution. Figure 2.3 shows the process of loading the ampules in a glove box.

The capillary needle was inserted through the septum port (prior to attaching a rubber septum) and reached all the way to the bottom of the ampule for dispensing the liquid. Care was taken not to smear any liquid on the wall when retracting the syringe needle. All this was done in a glove box under argon. The time at which the liquid was admitted to the sample was the starting time of the 30-day experiment at 298 K (25°C) since ambient temperature was not much different from the constant temperature bath. For the 338 K (65°C) tests, the samples would spend a few days at ambient before the constant temperature bath was heated to 338 K (65°C) and the 30-day count was started.

Mercury was introduced into the U-gauge manometer to fill both legs of the manometer to half their length. This gave a maximum readable pressure range once the gas evolution started. The mercury used was vacuum degassed and filtered through a pinhole prior to use. This was necessary not only to eliminate contaminants, but also to obtain a clean meniscus that is needed for accurately measuring the pressure to ±0.1 mm with a cathetometer.

Finally, a new rubber septum was placed on the septum port to seal it gas tight. After this final step, the loaded and tightly sealed ampules were removed from the glove box and inserted into the constant temperature bath. Figure 2.4 shows a completely assembled compatibility test ampule ready to be inserted into the constant temperature bath. Those ampules inserted into a 338 K (65°C) bath experienced some initial pressure rise from the thermal expansion of the gas in the vapor space ("ullage") alone. This slight overpressure was not vented due to the difficulty in re-connecting the septum tightly, the risk of suffering pressure loss during the 30-day test, and inadvertent introduction of air while the pressure of the 65°C warm sample is vented to ambient pressure. The initial travel of the mercury due to ullage warm-up thus reduced the travel remaining for the test before gas would bubble though the low portion of the U-manometer at the end of the test.

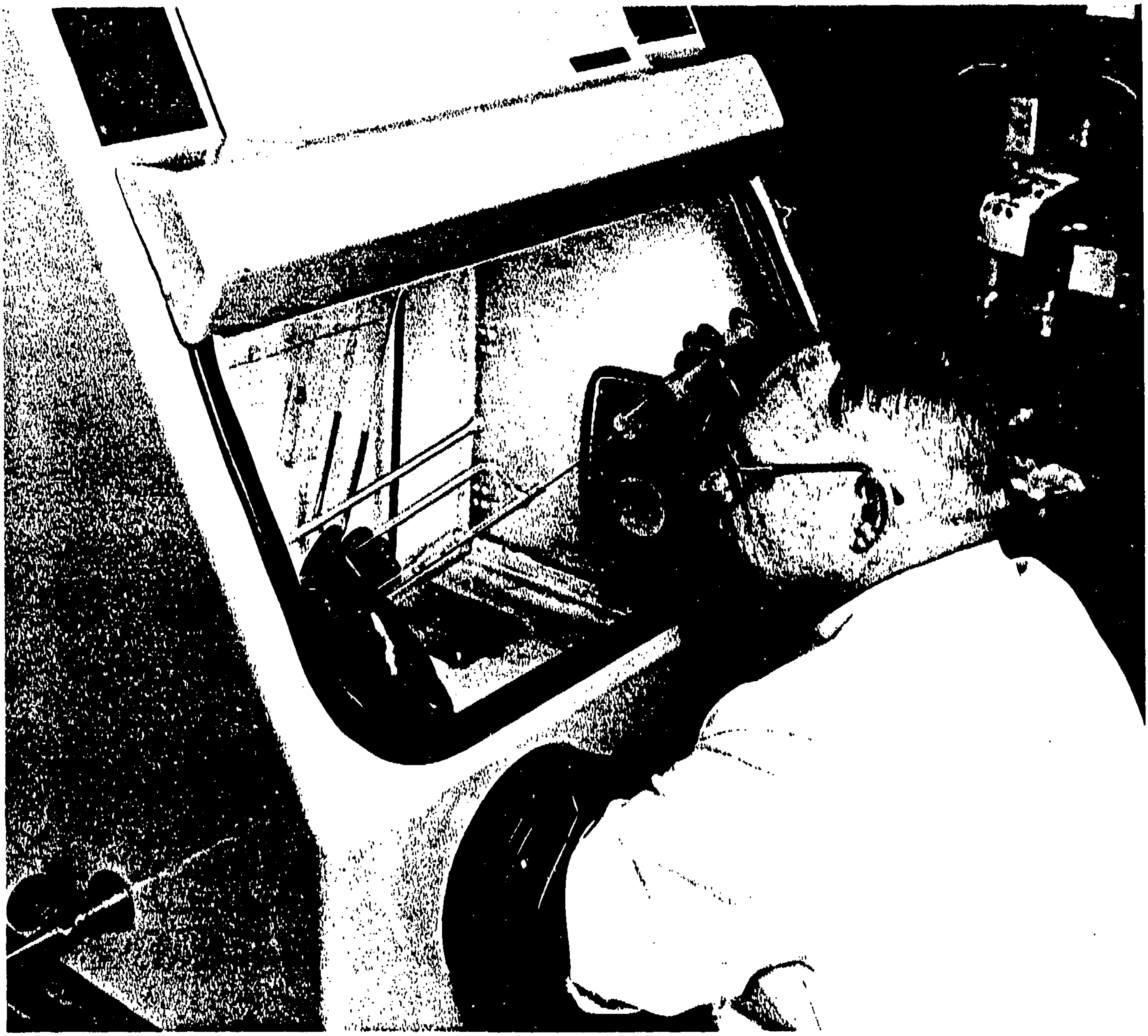

Figure 2.3: Loading of Ampules with HAN Solution under an Inert Atmosphere

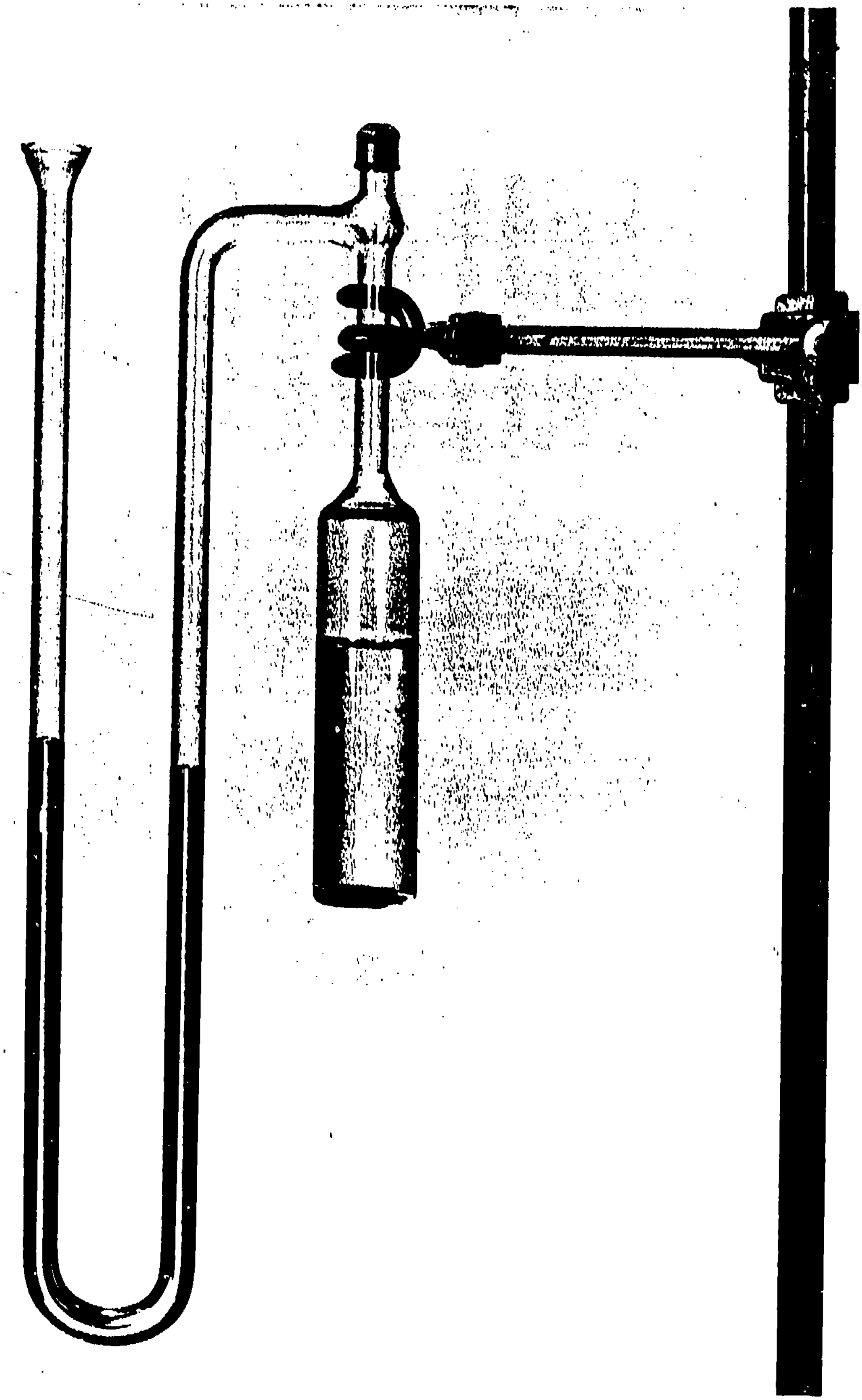

Figure 2.4: Compatibility Test Ampule Loaded with Sample and HAN Solution

The amount of gas evolved during the 30-day observation period was calculated from the ullage volume of the flask, the pressure read from the manometer, and the temperature and was reduced to standard conditions (Standard Temperature and Pressure = STP). The total volume of several of the flasks was determined by filling with water and weighing. The flasks were all constructed as identical as possible and flask-to-flask variations of total volume were held at a minimum. All manometers were filled to approximately the same mercury level at the beginning of the test. The ullage volume was calculated from the total internal volume minus the volume of liquid loaded into the ampule (40 cm^3). The sample itself did not occupy much volume and was ignored.

The length of the U-gauge was 34 cm from top to bottom of the U. The full scale range was 300 mm Hg corresponding to a gas evolution of approximately 16 cm^3 STP at 338 K. A widened section like a small funnel at the top of the open end of the U-gauge allowed gases to escape in the event of unintended overpressurization without spilling the mercury on the bench top or the floor. A catch pan was placed under the U-gauges to catch mercury spillage in the unlikely event of overpressure or glass breakage.

The vapor pressure of the HAN solution is lower than that of water and is similar to but somewhat higher than that of LGP-1846, i.e. approx. 12 mm Hg at 298 K (25°C) and 89 mm Hg at 338 K (65°C). It is part of the total pressure measured. The partial pressure of the vapor (the pressure reading at the beginning of the 30-day test period) was subtracted from the pressure read on the manometers prior to the calculation of the amount of gas formed. Minor fluctuations of the constant temperature bath temperature would cause vapor pressure fluctuations on the manometer. The bath temperature was kept constant to within $\pm$ 0.1°C in order to prevent pressure fluctuations.

Since the flasks and U-gauge manometers were open ended, the readings fluctuated with the ambient barometric pressure. The ambient barometric pressure was read each day when the samples were read and entered in the test log for future data reduction. This mode of testing with open-ended U-gauges has the disadvantage that it is sensitive to ambient pressure fluctuations, whereas other materials compatibility test methods are independent of ambient pressure fluctuations if the U-gauge is hermetically sealed under vacuum and not exposed to atmospheric pressure fluctuations (Reference [23]). Admittedly, the open-ended U-gauge ampules are easier to build and to fill and are perfectly adequate for tests where high rates of gas evolution must be expected. Their use is perfectly acceptable for initial compatibility testing where high accuracy is not required, but for those samples that show slow rates of gas evolution, it should be followed by long-term tests using hermetically sealed ampules like the one shown in Figure 2.5. The RRC-type apparatus is preferred for long-term compatibility testing with samples that have low rates of gas evolution.

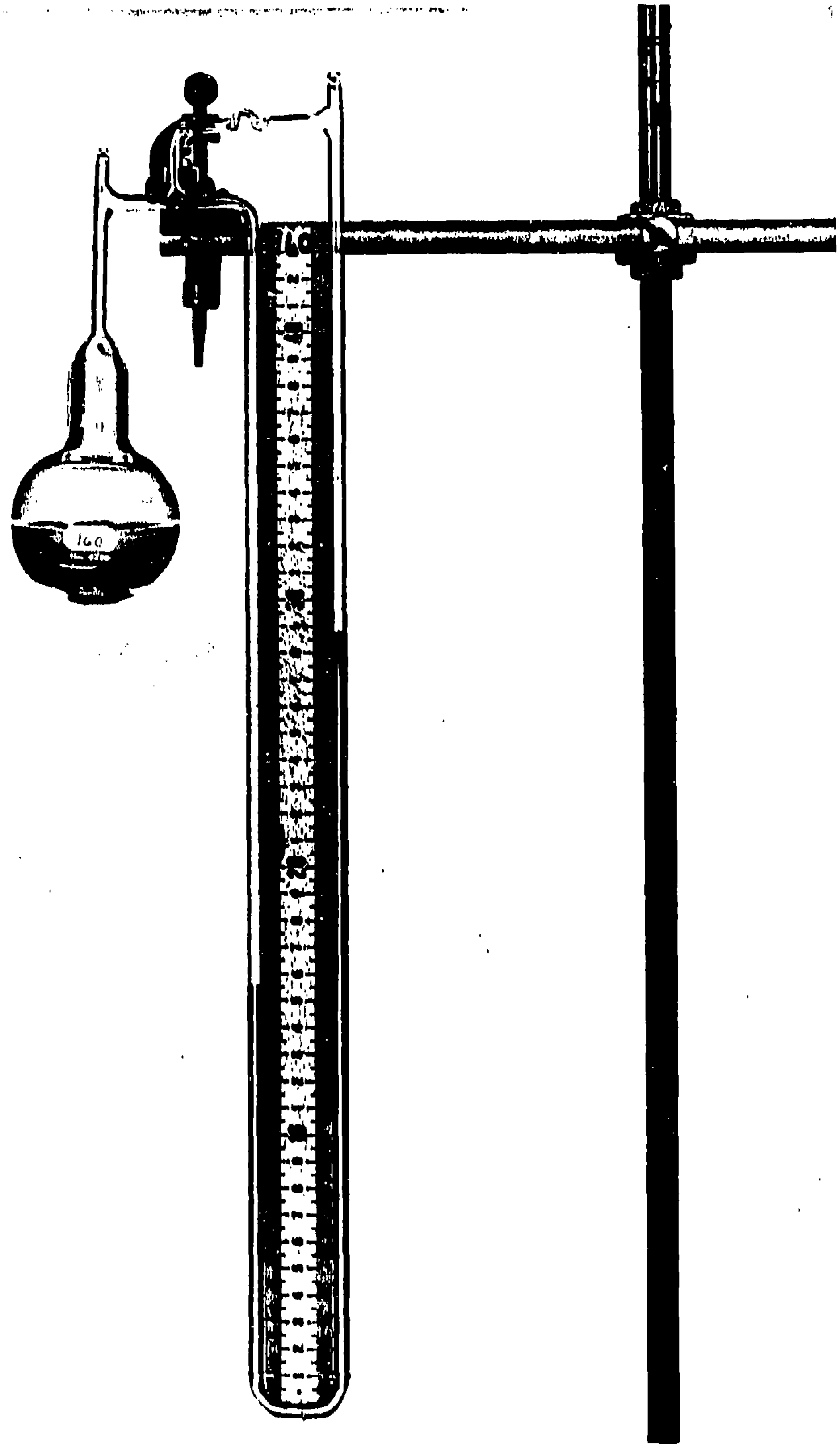

Figure 2.5: Hermetically Sealed Compatibility Test Apparatus (RRC Model)

2.4.2 Selection of Test Atmosphere

It is known that oxygen from ambient air can react with some of the materials in an acidic / strongly ionic solution and it may adversely affect the test results. When attempting to determine the solubility of oxygen in HAN solutions, it behaved anomalous since it apparently slowly reacts with the hydroxylammonium ion to produce nitrous oxide (Reference [24]).

It is also known that nitric oxide, should it form through the decomposition of hydroxylammonium nitrate, would become oxidized by oxygen to form nitrogen dioxide which would react with HAN, thus escaping analysis in the gas phase. Also, some oxygen may form during the decomposition of HAN solutions and if the ampules were not carefully freed from air to start with, one could not discern between oxygen formed from HAN reactions or oxygen present as a contaminant.

For these reasons, the tests were conducted under an atmosphere of argon. The glove box was purged with argon for several hours prior to loading and the absence of oxygen was verified by GC analysis of a grab sample taken from the glove box atmosphere. A large weather balloon was inflated inside the glove box to displace the previous atmosphere and to minimize the volume that needed to be purged. The ampules, the material specimens, the degassed hydroxylammonium nitrate solution, and the mercury were all placed into a glove box and purged with argon. The ampules were purged with argon, loaded with hydroxylammonium nitrate solution, and sealed with a rubber septum inside the glove box to prevent exposure to atmospheric oxygen. If the ampule initially contains only argon, it will then be possible to analyze for formed nitrogen, oxygen, or nitric oxidein the gas space above the sample at the end of the test.

However, argon and oxygen are difficult to separate on the molecular sieve column unless the gas chromatograph oven is cooled to below room temperature. It was thought to be advantageous to conduct the tests under a helium atmosphere instead of an argon atmosphere. For the very first series of 25 samples, helium instead of argon was used initially in the glove box to fill the ampules under an inert gas atmosphere. However, the rubber septums had an excessively high permeability to helium and the tests had to be abandoned and re-started after replacing the helium with argon (see Paragraph 3.2.2.1). Helium is not recommended for tests where rubber septums are used as seals. It was noted during tests at other organizations where seals for pressure gauges in HAN propellants were evaluated for compatibility and permeability that helium had the highest permeability of all gases under consideration (Reference [25]).

2.4.3 Selection of Total Immersion versus Partial Immersion

In order to maximize the possibility of detecting adverse reactions between the material and the liquid gun propellants, the entire samples were immersed in the liquid. This is in analogy to compatibility testing done by other organizations on LGP-1846.

There have been rare incidents where corrosion in the vapor phase above the liquid level was more severe than in the liquid itself. This can be caused by interaction of the liquid with the atmosphere above the liquid, resulting in a more corrosive environment than either liquid or vapor by itself. The current test method would not detect such types of corrosion.

It was noted that many of the materials coupons submitted for testing had a small hole drilled into one end, as if the samples were intended to be suspended from a wire such that only the lower portion was immersed in the liquid propellant. However, since no detailed instructions were given with the samples, the coupons were totally immersed in the propellant same as the other materials that did not have pre-drilled holes in them.

2.4.4 Selection of Sample Size

Most of the material specimens supplied by the contracting agency were small enough to fit through the 8-mm inner diameter neck of the ampules without further cutting. It appeared that many of the GFE samples provided by the contracting agency were cut by another government contractor to dimensions of 1 inch length by 1/4 inch thickness. These coupons were easily loaded into the ampules. Other materials submitted by the contracting agency for testing were oversize and had to be cut to size. Yet other materials, laminated multi-layer composites, coating materials, or glass ceramic coatings on a steel flange, could not be cut to size and had to be returned untested.

It was desirable to use as large a sample as possible in order to obtain measurable rates of gas evolution during the 30-day observational period. Therefore, provided that the material supplied was of sufficient width, the coupons were cut 65 mm length and 8 mm width, which is short enough to be completely immersed in the 40 mL of liquid, but long enough to provide a sufficient surface area (e.g. 11.9 cm^2 with a 1-mm = 0.04 inch thick flat coupon) to generate measurable gas evolution and metals leaching for those materials of marginal compatibility. Samples that were cut to size at RRC from larger stock were weighed and measured, cleaned with 2-propanol, dried, and bagged and sealed in polyethylene bags until ready to be used.

2.4.5 Selection of Sample Shape

The RFP did not prescribe the sample shape and previous reports on BRL- sponsored compatibility testing with LGP-1846 were not specific with regard to the sample shape (or even the surface area) of the specimens used. It was noted that many of the materials coupons submitted for testing had a small hole drilled into one end, as if the samples were intended to be suspended from a wire such that only the lower portion was immersed in the liquid propellant. However, since no other instructions were given, the samples were used as-received and totally immersed in the propellant.

Also, some materials coupons were coated with a coating, but the coating did not extend over the entire area of the coupon or the small hole, leaving some underlying metal exposed. The current method of testing unfortunately exposed the entire coupon, the coated and the uncoated area of the coupon. Future tests should use coupons were the entire surface area is uniformly coated.

It would be simplest to work with rectangular shaped flat coupons that are easy to machine or, in the case of elastomers, could even be cut to size with a scissors. However, in testing liquid rocket propellant material compatibility, it has become common practice to use dogbone-shaped tensile specimens per ASTM E8 which can be used for determination of tensile strength and yield at break. There exists an ASTM specification for static immersion testing of unstressed materials with dinitrogen tetroxide N_2O_4 (Reference [26]). This method should be adapted with some modifications for future materials compatibility testing with HAN solutions where not only materials chemical interactions, but also mechanical properties are studied. Another related test method for elastomers is ASTM D-471 (Reference [27]) which has been used by the United States Army Belvoir Research, Development & Engineering Center for testing the compatibility of elastomers with LGP-1846 (References [28] and [29]). This method can be combined with measurement of gas evolution and components leaching in future tests.

2.4.6 Selection of Test Duration

The test duration was 30 days , as prescribed by the solicitation RFP Scope of Work Par. 3.3.1. This duration is short in comparison to immersion tests commonly conducted with similar liquid rocket propellants. The accuracy of prediction from the short-term exposure test described here with liquid gun propellants is poor in comparison to the accuracy derived from the materials compatibility data base accumulated as the result of lengthy (2 to 20 years) testing with liquid rocket propellants. The tests now completed with HAN solutions and similar tests with complete mixtures of LGP-1846 can therefore be considered only as preliminary screening tests. It is recommended that they be followed up with longer tests using only those materials that are identified as compatible as the result of the current screening tests.

The test duration should be long enough that initially transient phenomena (induction periods, passivation) have stabilized by the time the test is completed. Conversely, it should be short enough that no valuable test time is wasted on incompatible materials which would most likely have to be eliminated in the next round of testing anyway.

A large number of ampules had to be opened and analyzed within a short time at the end of the 30-day test. Analysis of the first batch of 25 ampules should be completed before the next batch has to be pulled. Therefore, the test starts were staggered by several weeks. This allowed sufficient time to complete the analysis of the first group before the second group of 25 ampules had to be opened.

2.4.7 Selection of Test Temperatures

The two test temperatures were selected in accordance with the requirements spelled out in Par. 3.3.4 of the RFP. For the first groups of 2 times 25 ampules, the temperature of the constant temperature baths was allowed to be anywhere between 24 and 26°C, as long as it was kept constant to within ±0.1°C. Because some of the testing extended through the summer months, and the ambient temperature in the laboratory rose above 24°C, a water cooling coil was inserted into the water bath.

For the second group of 2 times 25 ampules, the temperature of the constant temperature baths was allowed to be anywhere between 64 and 66°C, as long as it was kept constant to within ±0.1°C. RRC selected 65°C as the nominal test temperature.

There have been efforts by other investigators to test materials compatibility and thermal stability of liquid gun propellants at temperatures above 65°C using a slightly different experimental technique (Reference 30). It would have been of interest to compare their results with the results from the program described here.

2.4.8 Constant Temperature Bath

A typical 298 K (25°C) constant temperature bath setup is shown in Figure 2.6. The use of water as the bath fluid was perfectly acceptable for 25°C tests. For the 338 K (65°C) tests, water evaporation was retarded by covering the surface of the liquid with styrofoam chips. The water level in the 65°C bath was adjusted every few days. Forced convection circulation was achieved by stirring motors with propellers on a single shaft. Temperature gradients in the baths were thus kept at a minimum. Condensation in U-gauge tubes was prevented by keeping the U-gauges warm by wrapping a removable insulation blanket around the bath (although they were not at exactly the same temperature as the sample ampule).

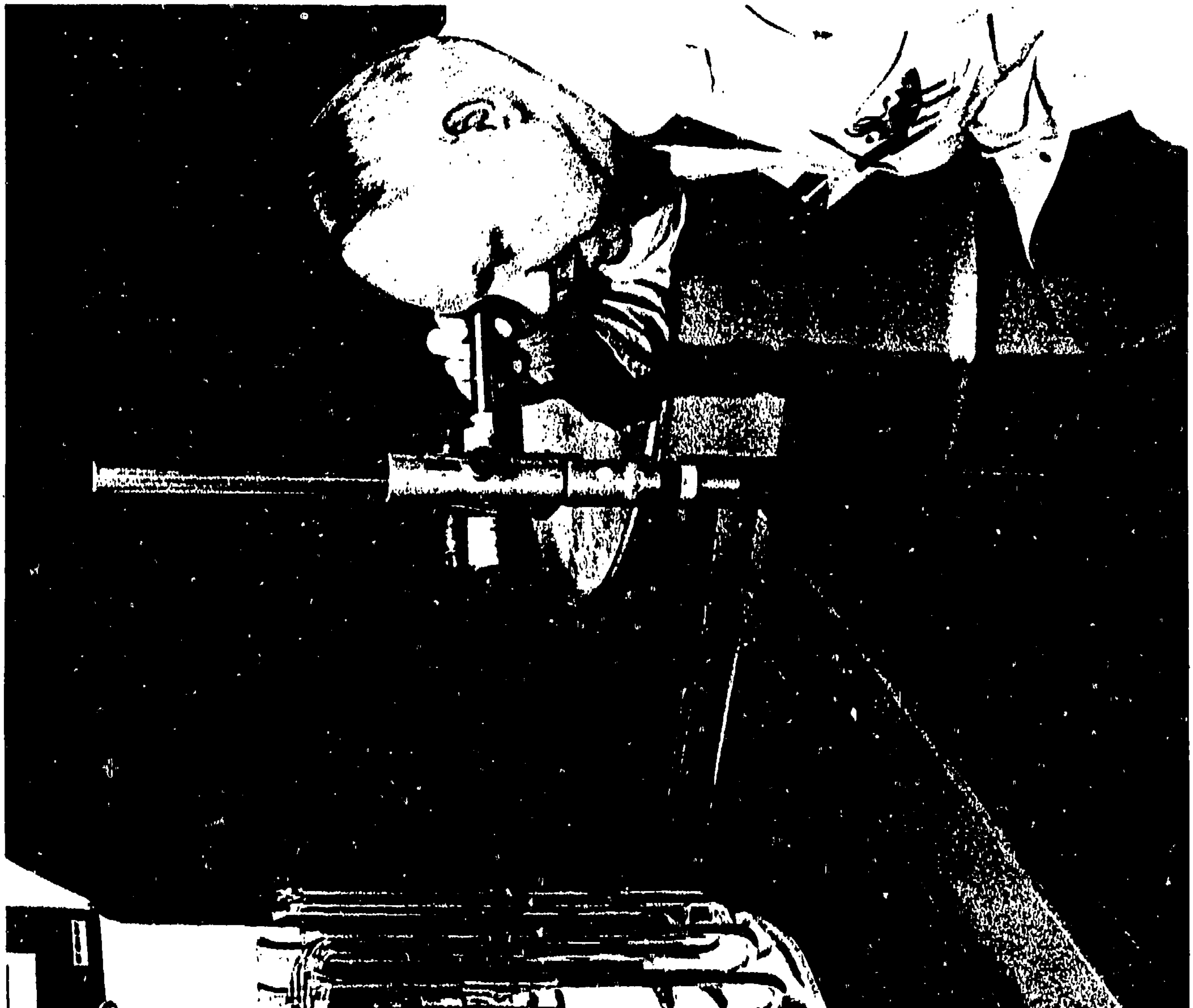

Figure 2.6: Constant Temperature Bath with 25 Ampules Prior to 25 °C Test

At least 25 ampules were placed together in one bath (per RFP requirement Par. 3.3.4). Each group of 25 ampules included one control without a material specimen in it. Previous investigators have also placed the ampules in the constant temperature bath such that only the sample ampule was at constant temperature and the U-gauge portion with the mercury was outside the bath, subject to ambient conditions as it was in the current test series. This method is acceptable since the vapor pressure of the solution is very low and condensation of the water in the upstream leg of the U-gauge is minimal. For the high-temperature tests at 338 K (65°C), the temperature of the U-gauges was very close to that of the baths due to conduction and radiation. An insulation blanket was wrapped around the entire bath while no readings are being taken.

The baths were placed on a rotary table ("lazy Susan") which allowed all four sides of the bath to be viewed so that the U-gauges could be read without having to move the cathetometer.

2.4.9 Measurement of Rate of Gas Evolution

The experiment consisted of measuring the gas pressure as a function of time. In accordance with Par. 3.3.3 of the RFP, the pressures were read at least once per day (excluding weekends or holidays), and more often if warranted by the extent of reaction. Care was taken to ensure that pressures were recorded near the end of the workday on Fridays and on days preceding legal holidays. Also, pressures were read at the beginning of the workday on Mondays and on days after legal holidays.

Pressures were read using a cathetometer with a nonius vernier scale. When the stirrer motor was turned off to eliminate vibrations of the mercury column while the readings were taken, pressure could be read to ±0.1 mm Hg with this instrument. The cathetometer was calibrated against a length standard (block gauge) traceable to the National Institute of Standards and Technology. The standoff distance between the cathetometer and the mercury manometers was typically 30 cm. This was close enough to avoid parallax errors. The cathetometer was aligned to true vertical with the aid of a spirit level.

2.4.10 Gas Evolution Data Reduction

The volume of the ampule and the attached glass tubing was measured at the beginning of the test series by filling on apparatus with water and weighing. The internal volume of the dry apparatus without mercury was 78.29 mL. Subtracting 40.00 mL for the volume of the HAN solution and neglecting the volume occupied by the test specimen, leaves an ullage volume of 38.29 mL. Earlier investigators had once proposed the following formula for calculating the amount of gas evolved in the course of the test and reducing it to standard temperature and pressure (STP):

$$V = [V_o\ (T_1/P_1)(P_2/T_2)] - [V_o\ (T_1/P_1)(P_o/T_2)]$$

where:

V	=	volume of gas produced, STP
V_o	=	initial "gas volume" (measured)
T_1	=	standard reference temperature, 273 K
P_1	=	standard reference pressure, 101 kPa = 760 mm Hg
P_2	=	current pressure (barometric pressure + manometer reading)
T_2	=	current bath temperature, K
P_o	=	initial pressure (barometric pressure + manometer reading)

This equation is in error since it does not sufficiently account for the fixed volume ("ullage") of the glass apparatus and its increase due to movement of the mercury. Instead, the following equation was used:

$$V = (T_0/P_0)\,[V_2\,(P_2/T_2) - V_1\,(P_1/T_1)]$$

where:

V	=	volume of gas produced, STP
T_0	=	standard reference temperature, 273 K
P_0	=	standard reference pressure, 101 kPa = 760 mm Hg
P_2	=	current pressure (barometric pressure + manometer reading)
T_2	=	current bath temperature, K
V_2	=	ullage, corrected for travel of mercury
P_1	=	initial pressure (barometric pressure + manometer reading)
T_1	=	initial temperature on day zero
V_1	=	initial ullage on day zero

2.4.11 Rate of Gas Evolution as Termination Criteria

Unscheduled Termination. Safety considerations dictated that the following gas evolution rates serve as termination criteria as defined in Pars. 3.3.6.2 and 3.3.6.3 of the RFP:

1. Any solution that generated more than 3 cm^3 (STP) of gas in one day was declared reactive and testing was terminated.

2. Any solution that generated more than 7 cm^3 (STP) of gas in 10 days at 25°C was declared **reactive** and testing on it was terminated at that time.

Fortunately, none of the sample solutions "fumed off" as the result of progressive contamination and self-acceleration of the decomposition reaction.

The materials furnished by the U. S. Government Contracting Agency were assured to be "intrinsically safe", that is, they were assured not be self reactive or hypergolically reactive with the HAN solution. Therefore, test tube screening or materials compatibility screening on the Differential Scanning Calorimeter (DSC) or Accelerating Rate Calorimeter (ARC) was not required. As a standard safety precaution, screening of new candidate materials should be conducted before enclosing them in a closed container together with any nitrate-containing monopropellants. The same precautions must be taken for HAN-based liquid gun propellants. It appears that for some of the lubricants and greases tested during the current program, DSC or ARC data were not yet available.

2.5 CHEMICAL ANALYSIS OF EVOLVED GASES

Other investigators have discovered the evolution of nitrogen and nitrous oxide as the result of incompatibility of HAN/TEAN solutions with metals (References 16, 19 and 20). Traces of oxygen were expected because the HAN solution would initially typically contain some dissolved air, although it was attempted to minimize the dissolved air by keeping the freshly concentrated 60% HAN solution in tightly closed bottles under a blanket of argon.

The evolved gases were analyzed in a gas chromatograph using argon as the carrier gas. Using argon instead of helium as the carrier gas made it possible to detect small oxygen peaks that otherwise would have been difficult to separate from the argon peak if helium was used as the carrier gas. As specified in Par. 3.3.5 of the RFP, only species comprising more than 5% by volume of the final volume (including the approximately 10 mL ullage argon that was initially in the apparatus) needed to be determined.

Some materials that are now shown to be incompatible resulted in such high rates of gas evolution that the full scale range of the manometer was exceeded in a few days. This was particularly true for several tests conducted at 338 K (65°C). Gas samples were drawn through the rubber septum into a gas-tight syringe and immediately injected into a gas chromatograph. Some contamination due to air intrusion into the needle while moving it the short distance from the test ampule septum to the GC port was inevitable using this method, in spite of the fact that the syringe and the needle was purged with sample gas several times prior to injection into the GC port. There was sufficient gas in the ullage to perform duplicate analyses on most samples.

Hydrogen, nitrogen and oxygen were analyzed on a 1.80 m x 6.2 mm (6 foot by 1/4 inch) molecular sieve (Linde 5A) column and nitrous oxide and carbon dioxide were analyzed on a 1.50 m x 6.2 mm (5 foot by 1/4 inch) Porapak Q column. Several gas chromatographs with both thermoconductivity and flame ionization detectors (FID) were available to support this program. Since the off-gasses did not contain organic compounds, it was not necessary to use the FID. The FID does not result in substantial improvement of sensitivity for nitrogen compounds.

The peaks were identified at the beginning of the program by measuring the retention times of synthetic mixtures spiked with known amounts of hydrogen, helium, oxygen, nitrogen, carbon dioxide, and nitrous oxide. When using argon as a carrier gas, the response for helium and hydrogen is much higher than for the other gases.

Nitrogen dioxide was not found by either GC or visual observation. Evolution of nitrous oxide fumes is typical for reaction of HAN solutions with materials containing copper. The red-brown color of this evolved gas would have been sufficient early warning that a reaction is taking place. In accordance with instructions in Par. 3.3.6.1 of the RFP, such specimens would have been immediately terminated and no further testing would have been required.

2.6 POST-TEST EXAMINATION OF SAMPLES AT END OF COMPATIBILITY TEST

2.6.1 Weight Change Measurements

Upon early termination or at the end of the test period, a final pressure reading was taken and a gas sample was drawn for gas analysis (see Par. 3.2.4). After completion of the gas analysis, which would typically take less than a day, the rubber septum was removed and the mercury was removed from the U-gauge with vacuum suction tube. The ampule was opened at the neck, the HAN solution poured out into a marked sample bottle, the material specimen taken out, rinsed with distilled water, and examined for visual appearance while still wet. The samples were then dried and weighed. The weighed samples were placed in polyethylene plastic bags, heat-sealed and packaged for shipment to the contracting agency for further examination.

2.7 ANALYSIS OF OFF-LOADED PROPELLANT

The following analyses were applied only to those material specimens that contained metals. No metal ion leaching was analyzed for polymer and grease samples that do not contain inorganic fillers. Some greases and anti-seize compounds contain molybdenum disulfide. In those instances, one would want to analyze for molybdenum in the off-loaded propellant.

It was one of the possible objectives of the future study to derive kinetic equations that will allow prediction of the rate of metals leaching at different environmental temperatures. In order to derive such equations, the rate of metal solubilizing has to be measured at at least two different temperatures. After the rates are obtained, the logarithm of the rate can be plotted in an ARRHENIUS graph versus the reciprocal absolute temperature. Extrapolations can be made to other temperatures assuming that the mechanism is the same over a wide range of temperatures.

It would be desirable to measure the metal concentration continuously throughout the 30-day duration of the experiment just like the rate of gas evolution is measured by taking daily data points. Instead, the metal concentration was analyzed only at the beginning and at the end of the 30- day immersion experiment. The only other alternative would be to use a very large experimental setup of the order of 200 mL liquid where the withdrawal of a 10-mL sample does not appreciably change the surface area : liquid volume ratio.

Candidate methods for the analysis of leached metals include atomic absorption spectroscopy (AAS), emission spectroscopy with conventional arc emission excitation sources, and inductively coupled plasma (ICP) emission spectroscopy. Each of these methods has its advantages and limited shortcomings and to a certain extent the various methods complement each other.

For ICP as well as AAS analysis, the off-loaded HAN solutions have to be diluted to reduce their viscosity to that of the standards in order to avoid errors caused by different nebulizer efficiency. In either method, the necessity to dilute the sample causes a loss of threshold detectability of the metals to be analyzed by more than one order of magnitude. Dilution may also be advisable for safety reasons to prevent accumulation of very concentrated HAN in the nebulizer.

In results reported by other investigators, metal contaminations in off-loaded LGP-1846 and 13-M HAN solutions after 1 to 13-week exposure to metals ranged from 0.6 to 43,000 ppm. In this range of metal concentrations, AAS is perfectly adequate and ICP is not needed. The improved sensitivity of ICP is only needed in the analysis of leached metals that have a very low rate of corrosion. ICP was used mainly for analysis of the received 24% HAN solution to certify that it did not contain an excessive amount of dissolved metals to start with.

A Perkin Elmer Model 1100B AAS spectrometer with a large number of lamps for different groups of elements was used on this program. Table 2.1 gives a summary of the lamps on hand, the elements that can be analyzed with these lamps, and the detection limit for each element in the as-analyzed solutions in comparison to detection limits with an ICP instrument.

Table 2.1: Comparison of AAS and ICP Detection Limits

	Detection Limit, ppm	
Element	AAS	ICP*
Al	1	0.01
B	13	0.01
Ca	0.15	0.01
Co	0.12	0.003
Cr	0.08	0.006
Cu	0.08	0.002
Fe	0.1	0.01
K	0.5	1.0
Li	0.05	0.02
Mg	0.01	0.01
Mn	0.5	0.002
Mo	0.7	0.01
Na	0.1	0.02
Ni	0.15	0.01
Pb	0.2	0.02
Si	2	0.04
V	2	0.002
Zn	0.02	0.002

* Thermo Jarrel Ash ICAP 61 Spectrometer at AmTest, Redmond

For metals analysis by AAS, a sample of the off-loaded propellant was diluted 1:1 with distilled water in a volumetric flask, filled to volume with distilled water and analyzed. If the analyte concentration was so high that it was out of the range of the instrument, an aliquot was diluted once again to bring the concentration down into the range of the instrument.

For achieving an optimum detection sensitivity, it was attempted to dilute the off-loaded HAN solutions as little as necessary. However, viscosity effects initially prevented reproducible results when using HAN concentrations above 30%.

In an effort to quantify viscosity effects on AA nebulizer performance, the time required to aspirate solutions containing different concentrations of HAN into the AA nebulizer were measured. The results are shown in Figure 2.7.

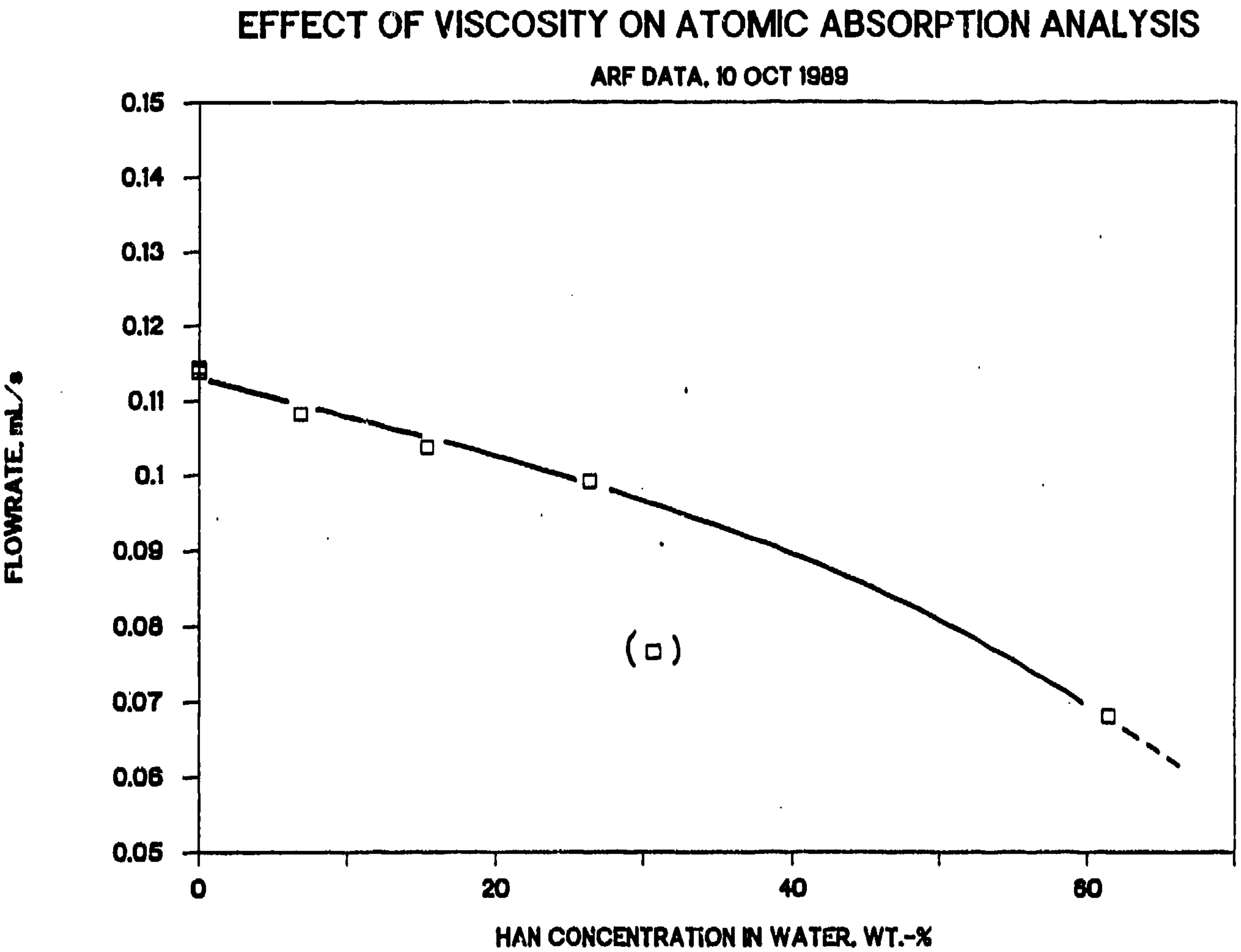

Figure 2.7: Flow Rate of HAN Solutions into AAS Nebulizer

As can be seen in this illustration, the analyte flow rate (and consequently the AA absorption signal) varies over a factor of 0.5 from HAN concentrations between 60 and 0 %. Thus, if standard solutions for calibrating the AAS were made up in water and undiluted 60% HAN was aspirated, the results could be off by a factor of two. In order to avoid the viscosity effects, the standards were made up in 24% HAN solution, and the off-loaded post-test solutions were also diluted to close to 24% HAN. In this way, viscosity effects were eliminated.

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Chapter 3

EXPERIMENTAL RESULTS

3.1 PRE-TEST ANALYSIS RESULTS

3.1.1 HAN Assay Analysis Results

3.1.1.1 As-Received 24% HAN Solution

A sample of the as-received 24% HAN solution was analyzed by both ICP and AAS to verify its compliance with the procurement specification. Table 3.1 shows the results of the ICP and AAS analysis in comparison to the spec requirements. Sample A was the as-received solution. Sample B was the same solution, but spiked with 200 ppb iron and submitted for analysis at the same time, but without providing knowledge of the iron addition to the analyst. This served as a double check on the accuracy of the iron analysis. Iron was the most likely contaminant and one of the contaminant that would be most deleterious to the type of testing that was planned with the 24% HAN solution.

As can be seen in Table 3.1, the ICP and AAS analysis at RRC agreed with the batch analysis provided by the supplier, Southwest Analytical Chemicals. The material was meeting the specification and was therefore accepted for the subsequent concentration step. The highest concentration of any cation was sodium with 1.27 ppm. There is currently no specification limit for sodium except that the total metals cannot exceed 5 ppm.

3.1.1.2 Concentrated 60.8% HAN Solution

The 24% HAN solution was concentrated in a rotavapor in several batches to just slightly above 60.8% HAN. Several batches analyzed initially at 64.9% HAN. The batches were combined in a large bottle, mixed, titrated for assay, and adjusted with distilled water to arrive at the desired nominal HAN concentration.

Table 3.1: HAN Acceptance Test Results

Property	SWAC Spec. % by wt or ppm	SWAC Batch Analysis % by wt or ppm	AmTest ICP ppm Sample A	AmTest ICP ppm Sample B**	AmTest Detection Limit, ppm	RRC by AAS ppm Sample A	RRC Detection Limit, ppm
Assay, %HAN	24 +/- 1%	24.80%					
Nitric Acid, molar	0.01	0.005					
Ash, ppm	<10	<10					
Sulfate, ppm	<10	<10					
Chloride, ppm		<3					
Ag, ppm			L*	L	0.01		
Al, ppm	<0.2	<0.1	0.039	—	0.01		
As, ppm			0.055	L	0.03		
B, ppm			0.151	0.235	0.01		
Ba, ppm	<0.1	0.1	0.011	0.011	0.003		
Be, ppm			L	L	0.007		
Ca, ppm			0.332	0.462	0.01	L	0.15
Ca+Mg, ppm	<10	<2					
Cd, ppm			L	L	0.002		
Co, ppm			L	L	0.003		
Cr, ppm			0.008	0.009	0.006	L	0.08
Cu, ppm			0.004	L	0.002	L	0.08
Fe, ppm	<0.2	0.03	0.053	0.218*	0.01	L	0.1
Hg, ppm			L	L	0.01		
K, ppm			L	L	1		
Li, ppm			L	L	0.02		
Mg, ppm			0.087	0.090	0.01	L	0.01
Mn, ppm			L	L	0.002		
Mo, ppm			L	L	0.01		
Na, ppm			1.24	1.27	0.02		
Ni, ppm			L	L	0.01	L	0.15
P, ppm			L	L	0.05		
Pb, ppm			L	L	0.02		
S, ppm			1.5	1.5	0.1		
Sb, ppm			L	L	0.02		
Se, ppm			L	L	0.03		
Si, ppm			0.376	0.489	0.04		
Sn, ppm			L	L	0.02		
Sr, ppm			0.004	0.004	0.003		
Ti, ppm			L	L	0.01		
Tl, ppm			L	L	0.03		
Y, ppm			L	L	0.002		
V, ppm			L	L	0.001		
Zn, ppm			0.054	0.049	0.002		

* L = at or below detection limit

** Sample B spiked with 200 ppb iron

The concentrated solution was again analyzed for iron which is the contaminant of primary concern. The results are shown in Table 3.2 in comparison to the iron concentration in the original 24% solution. As expected, the iron concentration in the solution increased as the result of concentrating the solution. However, the ratio of iron increase is the same as that of the volume decrease. This proves that no additional iron was inadvertently introduced during the concentrating step. The same was true for magnesium and calcium.

Table 3.2: Analysis of Concentrated HAN Solutions

Contaminant Metal ppm	RRC Results (AAS) Original 24% HAN	Concentrated 60.8% HAN	Ratio after: before Concentr.	Sundstrand Results (Reference 18) 24% HAN	60% HAN
Fe	0.08	0.2	2.8	<0.5	<0.5
Mg	0.07	0.2	3.0		
Ca	0.14	0.47	3.4		
Ni	0.14			0.4	1.4

3.2 POST-TEST RESULTS

3.2.1 Weight Change Measurements

Table 3.3 gives a summary of the weight changes observed as the result of immersion in 60.8% hydroxylammonium nitrate. This table is subdivided in two portions, one on the 298 K (25°C) tests, the other on the 338 K (65°C) tests.

The samples in Table 3.3 are arranged by sample number. Sample numbers above 70 were already pre-assigned to the specimens by other BRL contractors when they arrived at RRC. It appears the same sample numbers were used by other BRL contractors and it was considered best to keep these numbers instead of assigning new numbers. The numbers are not in an uninterrupted sequence. Missing numbers therefore do not represent missing samples. It may be more convenient to arrange the samples in alphabetical order by material name or group them by the type of material. This was done in a database which will be provided to the contracting agency in computer-readable form. A partial printout of the database showing the materials samples arranged by material name and grouped by type of material is shown in Appendix A.

Sample numbers 1 through 21 were assigned by RRC to a group of mostly nonmetallic materials that was submitted for testing after the program had already started. These materials were in irregular shapes and had to be cut at RRC to fit into the apparatus.

Sample No. 311A, MG 120 Silver Solder, partially dissolved and formed sludge on the bottom of the ampule. 9.6% by weight of the metal was lost. A sample of the same material that was in test at 65°C (Sample No. 311B) was covered with white and yellowish sludge and actually gained some weight due to adhering crusts of deposits. Sample No. 5A, a carbon (graphite) bearing, had gained 2% weight, but the appearance was unchanged.

For grease samples, only the initial weight or volume was recorded. It was not possible to quantitatively remove the grease from the ampule after the test and separate it from the HAN solution. For oil samples, only the approximate initial volume was recorded. The surface area used for the calculations was the internal diameter of the ampule, the interface between the two immiscible layers.

After completion of the test, the samples were removed from the solution, rinsed with distilled water, and dried at room temperature. The plastic samples were not dried to constant weight. If they contained absorbed moisture, it would show in the weight gain values in Table 3.3.

Table 3.3: Weight Change of Test Specimens at 298 K and 338 K (25 and 65°C)

Speci-men No.	TRADE NAME	Initial Wt., g	Final Wt, g	% Wt Change
From first batch at 298K (25°C)				
73	CRES-301	0.1260	0.1261	+0.079
74	CRES-304	0.2401	0.2402	+0.042
75	17-7PH (Mill annnealed)	0.1260	0.1260	+0.000
112	Haynes Alloy 255	5.5528	5.5528	+0.000
113	Ferralium Alloy 255	4.6885	4.6883	-0.004
120	Tristelle Alloy T5-2	3.7854	3.7855	+0.003
134	Stellite #8 on 17-4PH	4.0220	4.0165	-0.137
135	Stellite #6 Nicraly on 17-4	4.1025	4.0965	-0.146
145	Silicon carbide PS-9242	1.6675	1.6674	-0.006
162A	UCAR LW-15 on 17-4	4.8963	4.8963	+0.000
163A	UCAR LC-1H on 17-4	4.0817	4.0818	+0.002
165A	Molydag on 17-4 PH	3.3400	3.3388	-0.036
166A	Nitrided Tribocor 532N	14.0432	14.0432	+0.000
179A	Ag Plate on 17-4 PH	3.8449	3.8445	-0.010
220A	Sermatech GC-WC-111 17-4 PH	4.5658	4.5669	+0.024
258A	Tantalum coating	3.4882	3.4882	+0.000
263A	CRES-316	3.5930	3.5928	-0.006
266A	Tungsten weld rod	2.3667	2.3658	-0.038
268A	CRES-302	3.7613	3.7613	+0.000
269A	CRES-308	4.1095	4.1094	-0.002
306A	15-5 PH	3.2069	3.2065	-0.012
310A	Nickel flash on 17-4 PH	3.7000	3.6975	-0.068
326A	Al-6061	1.3490	1.3278	-1.572
351A	Steel MP35N	4.0919	4.0918	-0.002

Table 3.3 (Continued) Weight Change of Test Specimens at 298 K and 338 K (25 and 65°C)

Speci- men No.	TRADE NAME	Initial Wt., g	Final Wt, g	% Wt Change
From second batch at 298 K (25°C)				
2A	Tefzel lining	5.3221	5.3221	+0.000
3A	Kynar lining	7.0136	7.0094	-0.060
5A	Carbon bearing	2.4353	2.4857	+2.070
6A	Ceramic thrust washer	0.9537	0.9537	+0.000
7A	Superproline	2.2142	2.2140	-0.009
17A	Zirconium Zr-702	5.8194	5.8194	+0.000
18A	Zirconium Zr-705	4.6943	4.6943	+0.000
19A	Silicon carbide	8.0010	8.0005	-0.006
116A	Graphitar Grade 47	1.0025	1.0028	+0.030
126A	Grease 3451	2.0376		
129A	Victrex 4800G	0.6932	0.6933	+0.014
130A	Victrex Gr. 4101GL20	0.7874	0.7876	+0.025
146A	Arlon 1160	0.7379	0.7379	+0.000
147A	Arlon 1260	0.8178	0.8178	+0.000
156A	Paxon BA 50-100	0.4790	0.4790	+0.000
158A	Aeroshell 17	1.50		
161A	Rulon II	0.7983	0.7990	+0.088
259A	Polyvinylchloride tubing	1.3076	1.3076	+0.000
311A	MG 120 Silver solder	0.7536	0.6811	-9.620
335A	Brayco 783E Micronic	2.1 mL		
396A	Aeroshell 14	1.50		
402A	10W-30 Motor Oil	2.1 mL		
412A	SAE 50W Motor Oil	2.8 mL		
446A	Galden D20	2.8 mL		

Table 3.3 (Continued) Weight Change of Test Specimens at 298 K and 338 K (25 and 65°C)

Specimen No.	TRADE NAME	Initial Wt., g	Final Wt, g	% Wt Change
From first batch at 338 K (65°C)				
2B	Tefzel lining	5.8561	5.8557	-0.007
3B	Kynar lining	6.8989	6.8895	-0.136
5B	Carbon bearing	2.9367	2.9371	+0.014
6B	Ceramic thrust washer	0.6465	0.6465	+0.000
7B	Superproline	2.0844	2.0842	-0.010
17B	Zirconium Zr-702	5.8742	5.8741	-0.002
18B	Zirconium Zr-705	4.7359	4.7359	+0.000
19B	Silicon carbide	8.5881	8.5878	-0.003
162B	UCAR LW-15 on 17-4	4.5640	4.5619	-0.046
163B	UCAR LC-1H on 17-4	3.6345	3.6342	-0.008
165B	Molydag on 17-4 PH	3.6912	3.6889	-0.062
166B	Nitrided Tribocor 532N	13.9628	13.9626	-0.001
179B	Ag Plate on 17-4 PH	3.6719	3.6714	-0.014
220B	Sermatech GC-WC-111 on 17-4	4.7933	4.7925	-0.017
258B	Tantalum coating	3.8550	3.8547	-0.008
263B	CRES-316	3.5865	3.5863	-0.006
266B	Tungsten weld rod	2.4004	2.3991	-0.054
268B	CRES-302	3.9264	3.9260	-0.010
269B	CRES-308	4.0880	4.0828	-0.127
306B	15-5 PH	3.1550	3.1545	-0.016
310B	Nickel flash on 17-4 PH	3.1184	3.1158	-0.083
311B	MG 120 Silver solder	0.6432	0.7494	+16.5
326B	Al-6061	1.3051	1.2777	-2.099
351B	Steel MP35N	3.9613	3.9603	-0.025

Table 3.3 (Continued) Weight Change of Test Specimens at 298 K and 338 K (25 and 65°C)

Speci-men No.	TRADE NAME	Initial Wt., g	Final Wt, g	% Wt Change
From second batch at 338 K (65°C)				
73B	CRES-301	0.1261	0.1260	-0.079
74B	CRES-304	0.2402	0.2401	-0.042
75B	17-7 PH (Mill annealed)	0.1260	0.1259	-0.079
112B	Haynes Alloy 255	5.5527	5.5527	+0.000
113B	Ferralium Alloy 255	4.6883	4.6882	-0.002
116B	Graphitar Grade 47	1.0028	1.0037	+0.090
120B	Tristelle Alloy T5-2	3.7856	3.7855	-0.003
126B	Grease 3451	2.5800		
129B	Victrex 4800G	0.6933	0.6923	-0.144
130B	Victrex Gr. 4101GL20	0.7876	0.7868	-0.102
134B	Stellite #8 on 17-4PH	4.0164	4.0152	-0.030
135B	Stellite#6 Nicraly on 17-4	4.1025	4.0929	-0.234
145B	Silicon carbide PS-9242	1.6674	1.6673	-0.006
146B	Arlon 1160	0.7372	0.7376	+0.054
147B	Arlon 1260	0.8172	0.8179	+0.086
156B	Paxon BA 50-100	0.4788	0.4788	+0.000
158B	Aeroshell 17	3.1531		
161B	Rulon II	0.7990	0.7990	+0.000
259B	Polyvinylchloride tubing	1.2852	1.2428	-3.299
335B	Brayco 783E Micronic	2.1 mL		
396B	Aeroshell 14	2.7203		
402B	Kendall 10W-30 Motor Oil	2.1 mL		
412B	Valvoline SAE 50W Motor Oil	2.8 mL		
446B	Gladen D20	2.8 mL		

Note:

Samples No. 73B thru 145B have been used for a previous test at 25°C and had to be re-used after intermediate examination (as directed by BRL).

3.2.2 Pressure Rise / Gas Evolution Measurements

The gas evolution curves of more than 100 tests are shown in Figure 3.1 through 3.15. There are two different formats for presentation of gas evolution curves:

1. Gas volume reduced to STP conditions (273 K, 101 kPa). The ordinate scale unit of these graphs is cm^3.

2. Gas volume reduced to STP conditions (273 K, 101 kPa) and divided by the surface area of the specimen ("normalized by the surface area"). The ordinate scale unit of these graphs is cm^3/cm^2.

The rationale for using the "normalized" volume of evolved gas (units of cm^3/cm^2) rather than the volume itself (units of cm^3) should be explained here. In the course of thousands of similar compatibility tests it has been found most useful to divide the amount of gas evolved by the wetted surface area of the specimen, in the assumption that the decomposition of the monopropellant is mostly surface catalyzed (heterogeneous catalysis) or that the amount of metal ions leached and causing homogeneous decomposition in the fuel is also proportional to the amount of surface area exposed. Quite often, looking at a graph containing data obtained with specimens of different shapes such as those used during the contract, the observer forgets the fact that the specimens were not of equal shape and may draw wrong conclusions about the compatibility of a material of construction with the liquid propellant. It was therefore recommended that the *normalized* gas volume be plotted in the graphs. The ultimate raw gas volumes (Unit cm^3) are listed in a separate table format in case they are needed for additional data reduction and pressure rise predictions at BRL.

For the control (blank) ampule, which does not have a surface area, a fictitious surface area of 10 cm^2 was assumed which is typical for many of the specimen coupons. The number is also easy for converting from one unit to the other. Use of a surface area of 1.0 cm^2 for this purpose would be even more convenient, but would result in excessive distortion and shift of the blank curves in the graphs.

3.2.2.1 Gas Evolution at 298 K (25°C)

The gas evolution measurements at 298 K (25°C) were very uneventful and the graphs Figure 3.1 through 3.5 are therefore presented in one format only, the format where the direct volume is presented without division by the surface area.

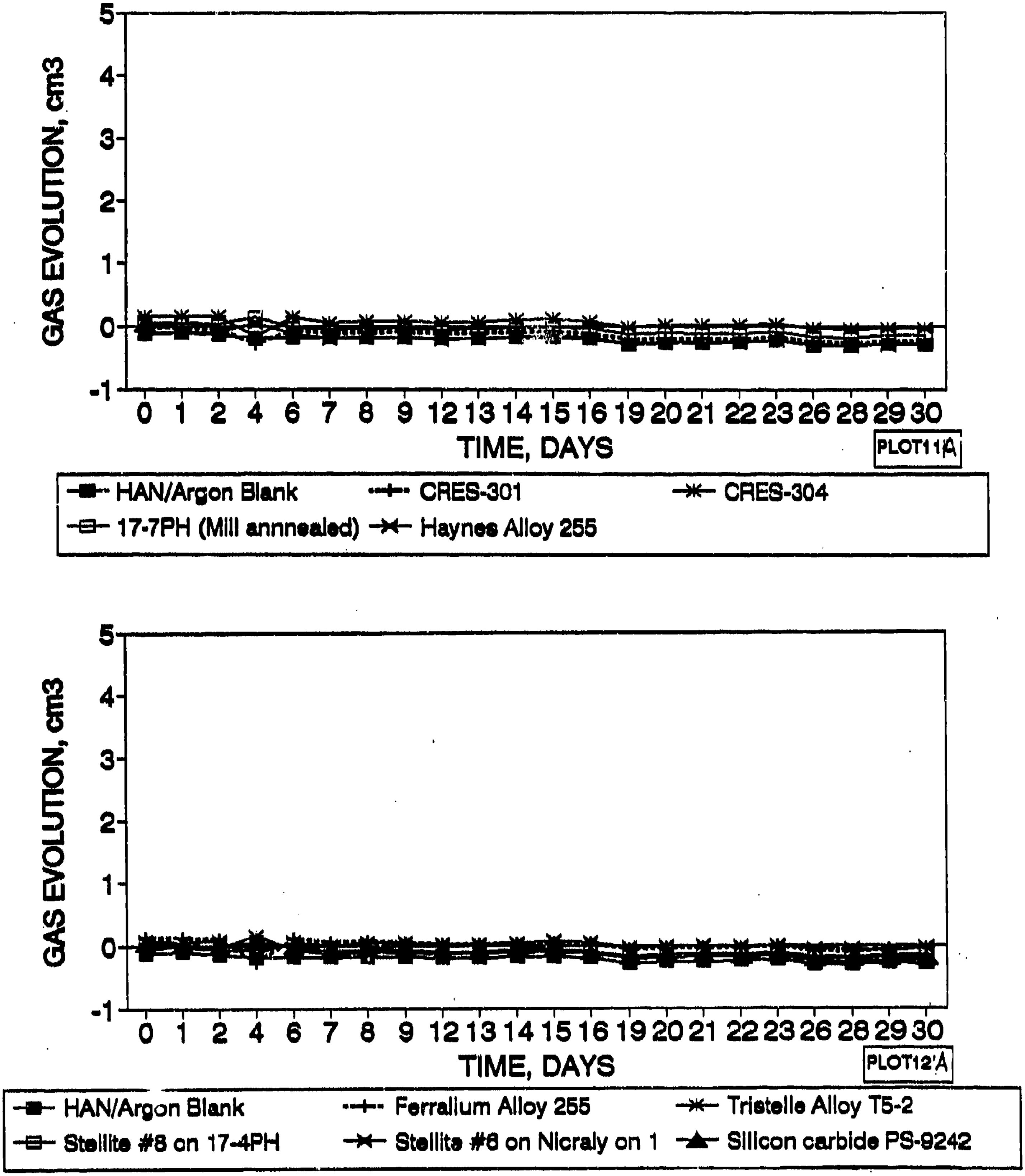
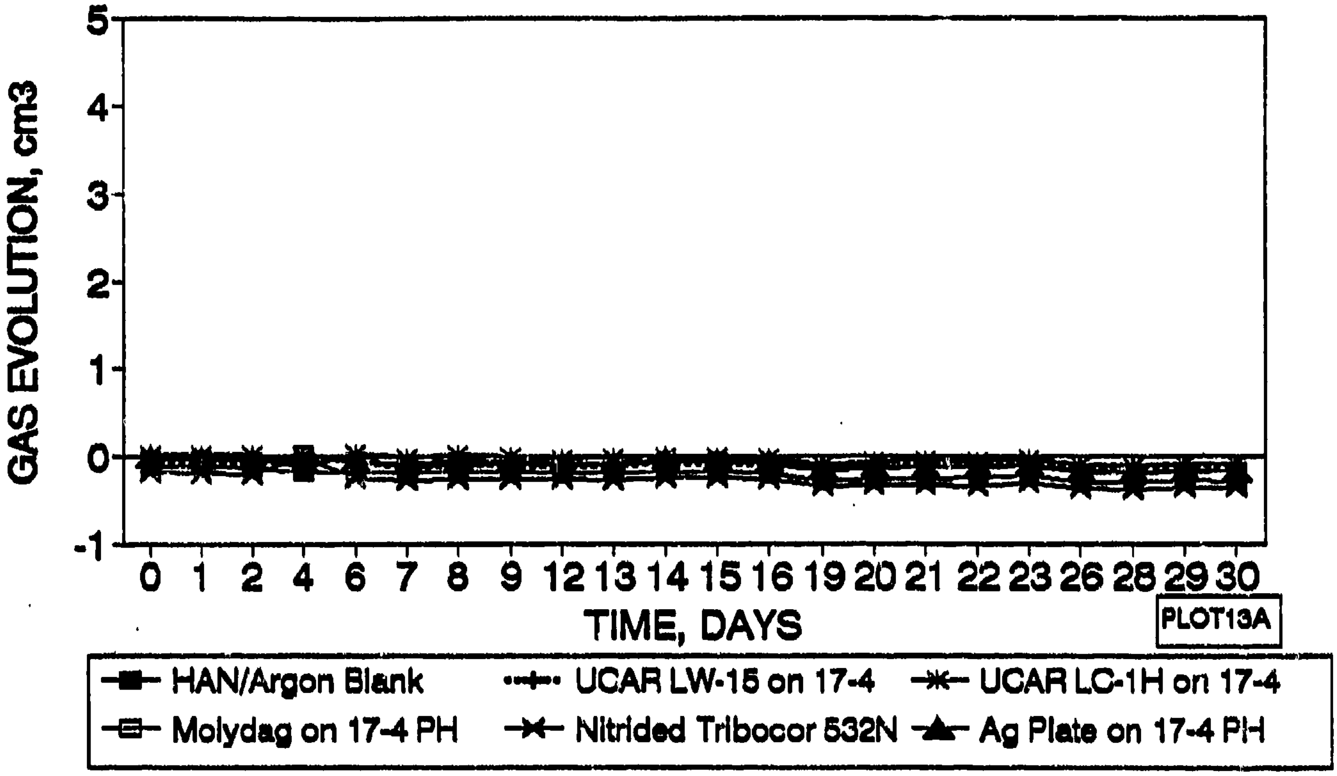


Figure 3.1: Compatibility of Materials in 60.8% HAN at 298 K (25°C)



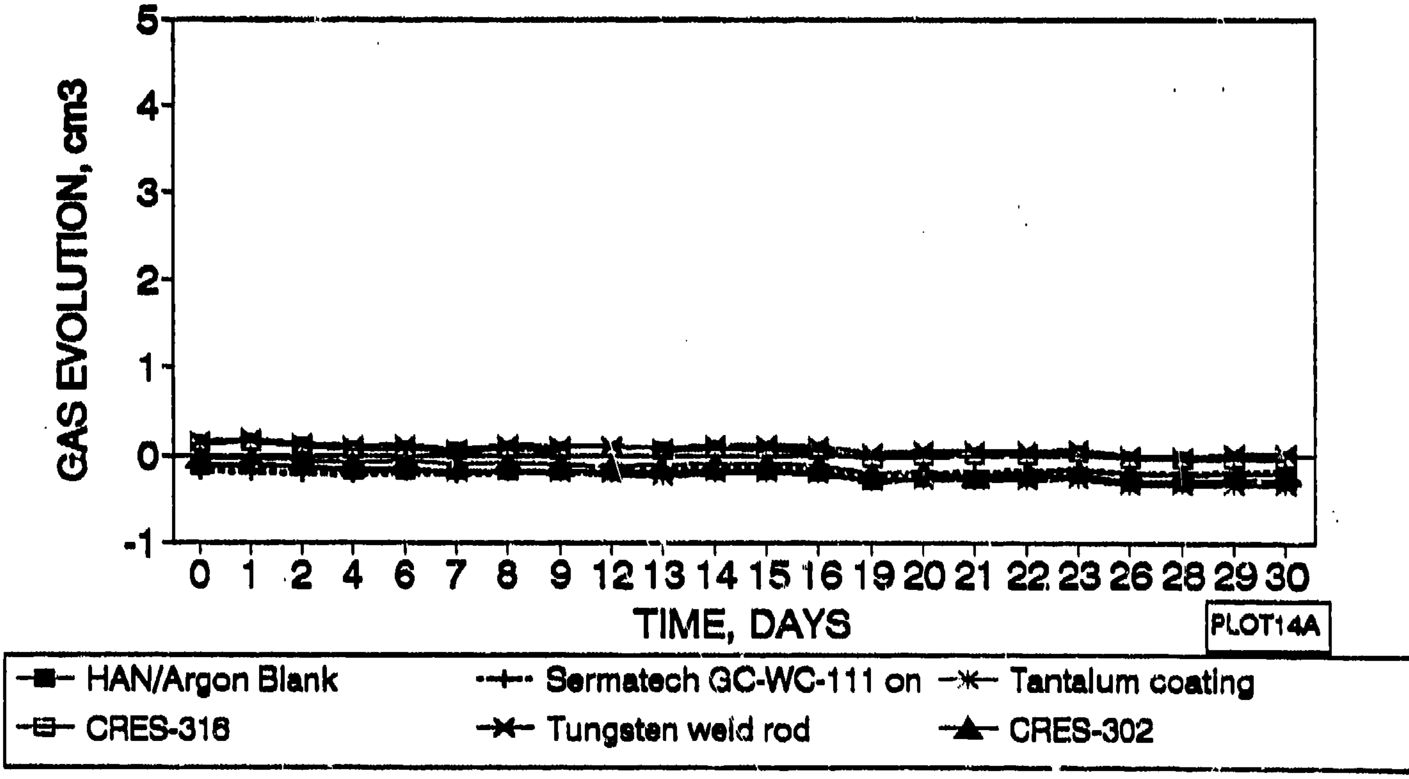
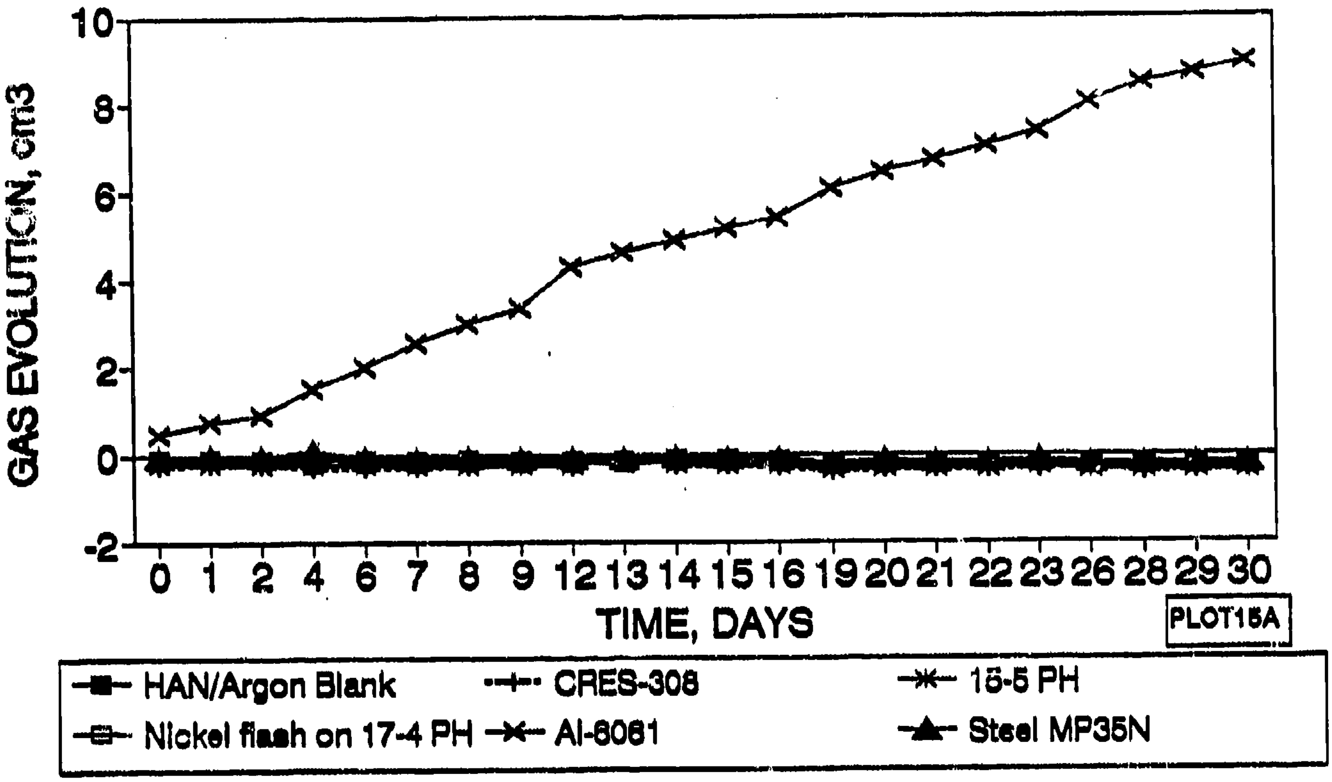


Figure 3.2: Compatibility of Materials in 60.8% HAN at 298 K (25°C)



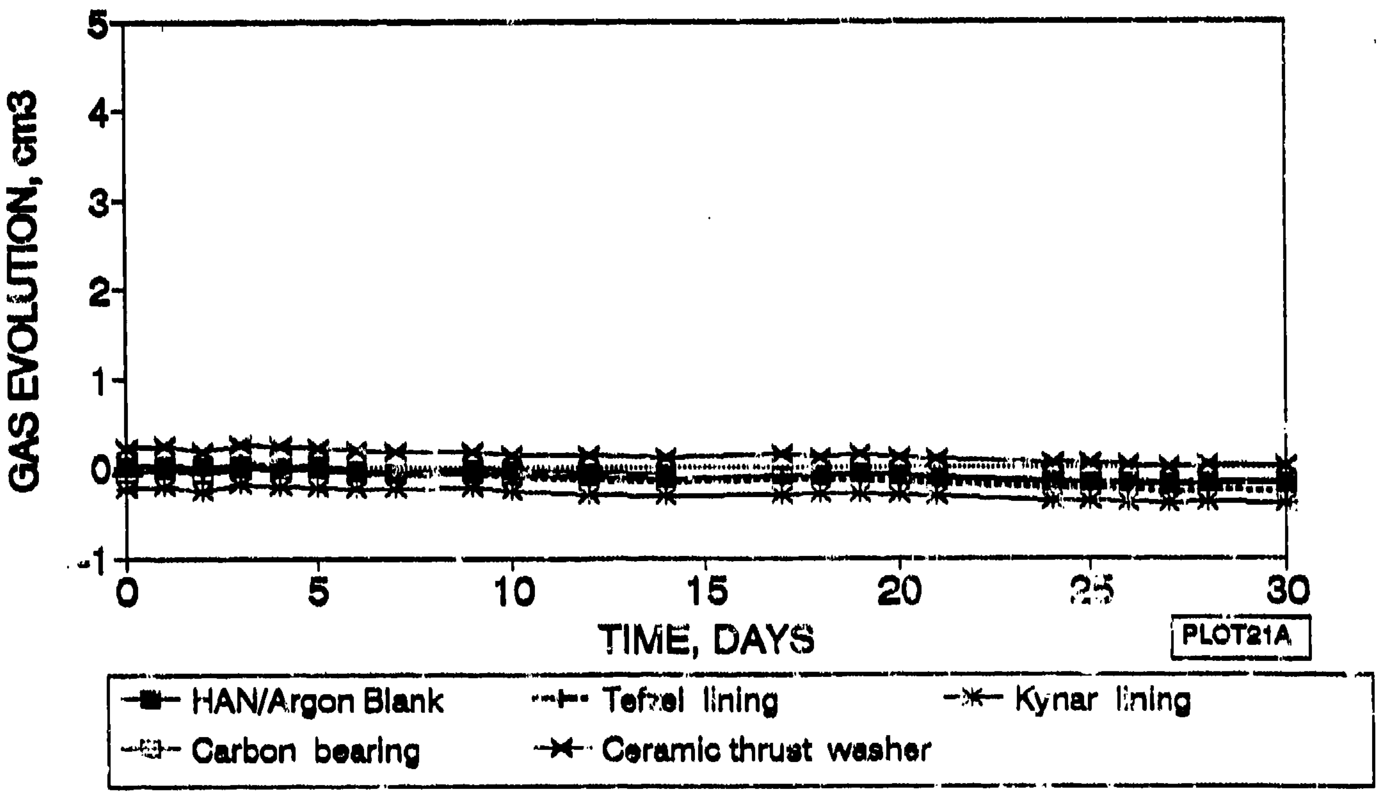
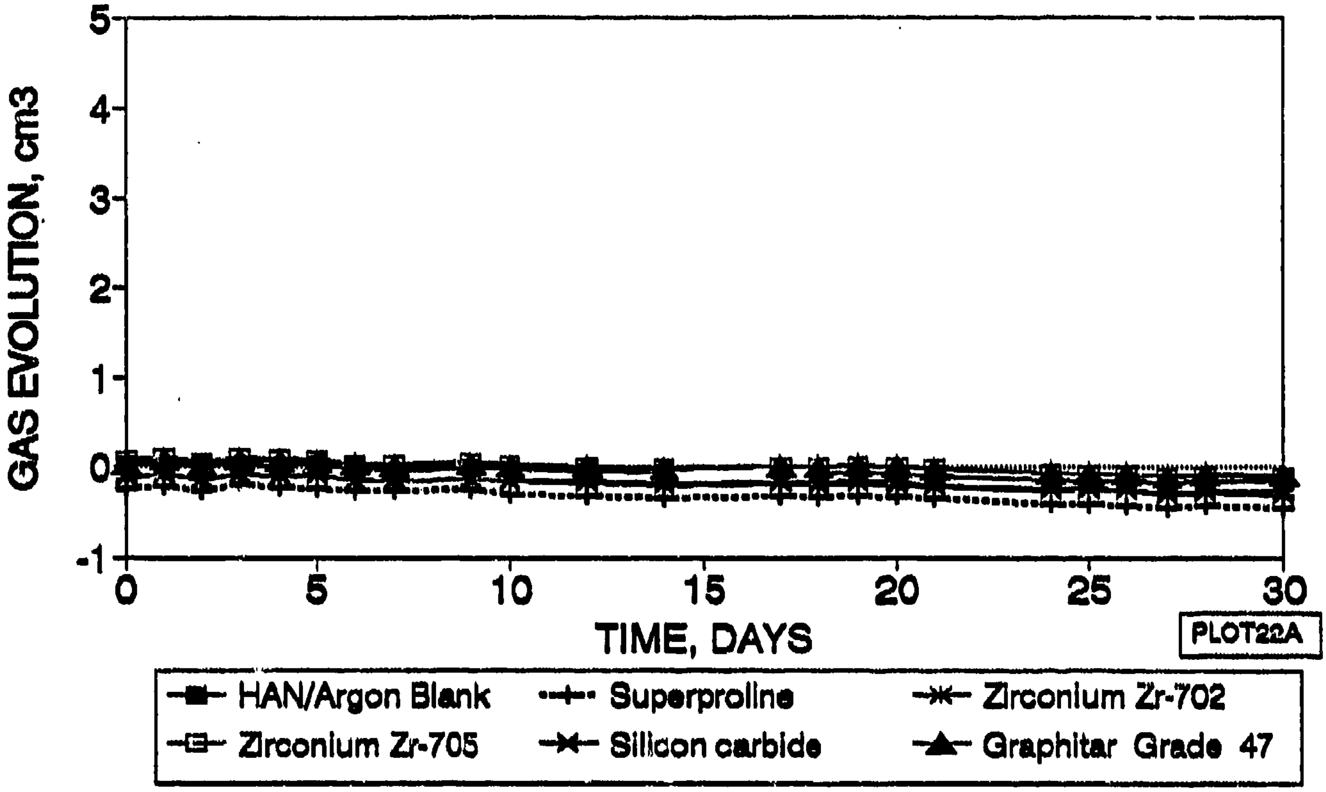


Figure 3.3: Compatibility of Materials in 60.8% HAN at 298 K (25°C)



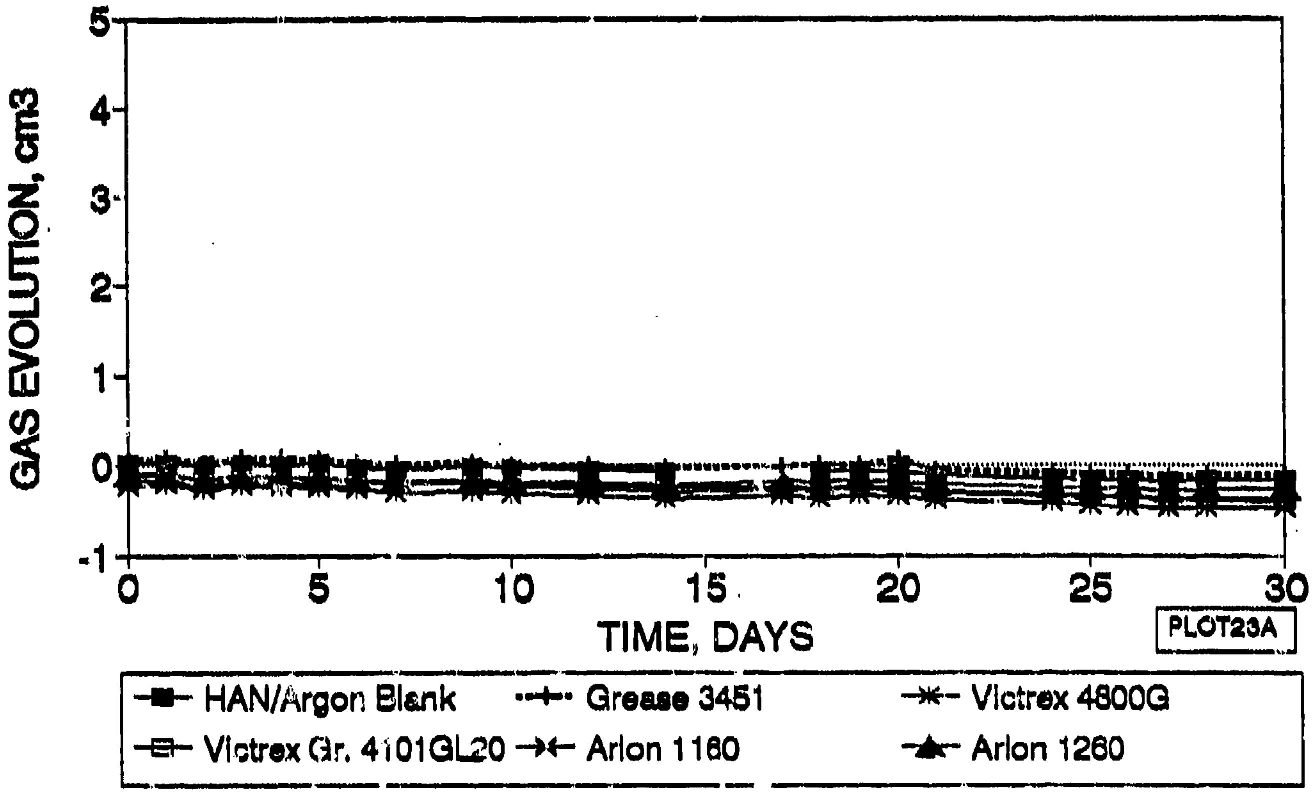
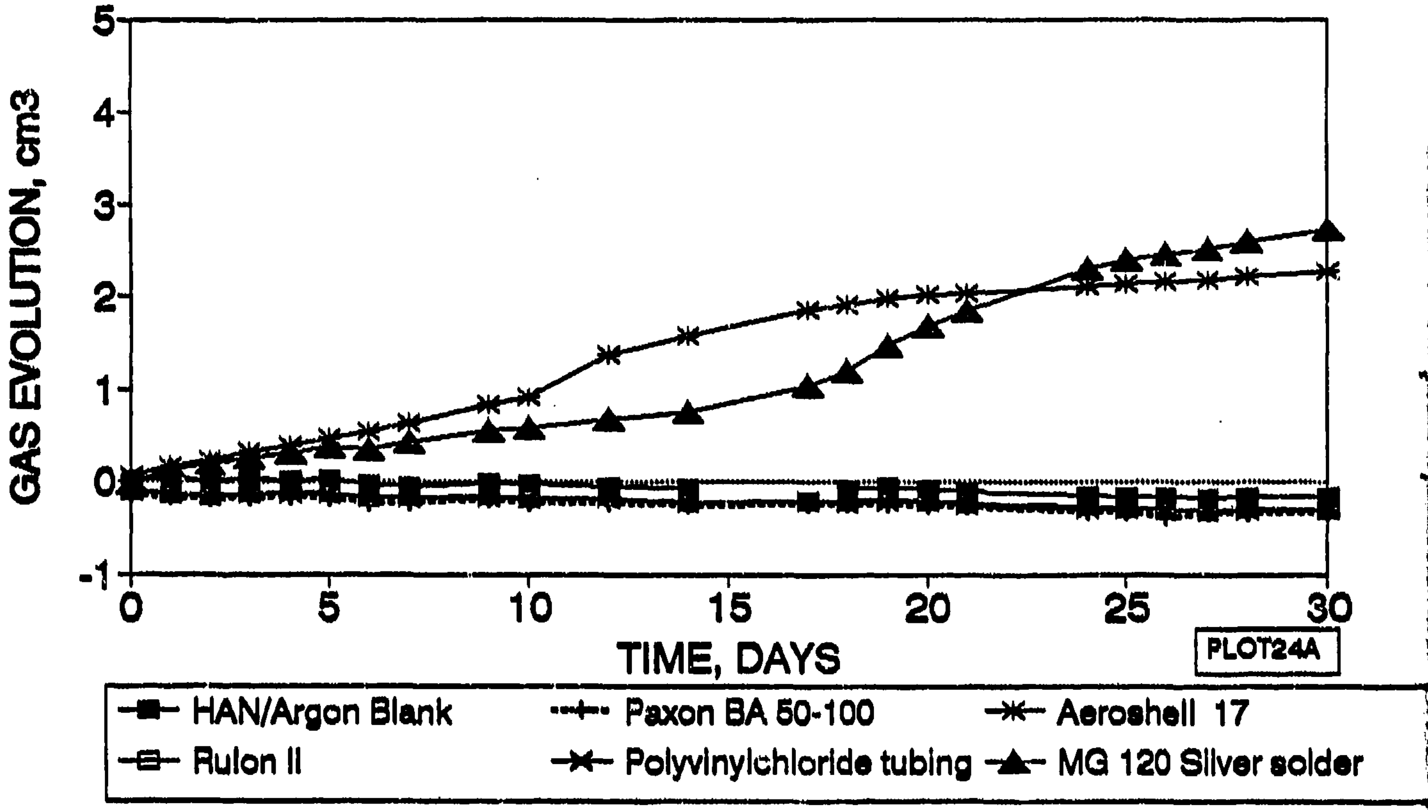


Figure 3.4: Compatibility of Materials in 60.8% HAN at 298 K (25°C)



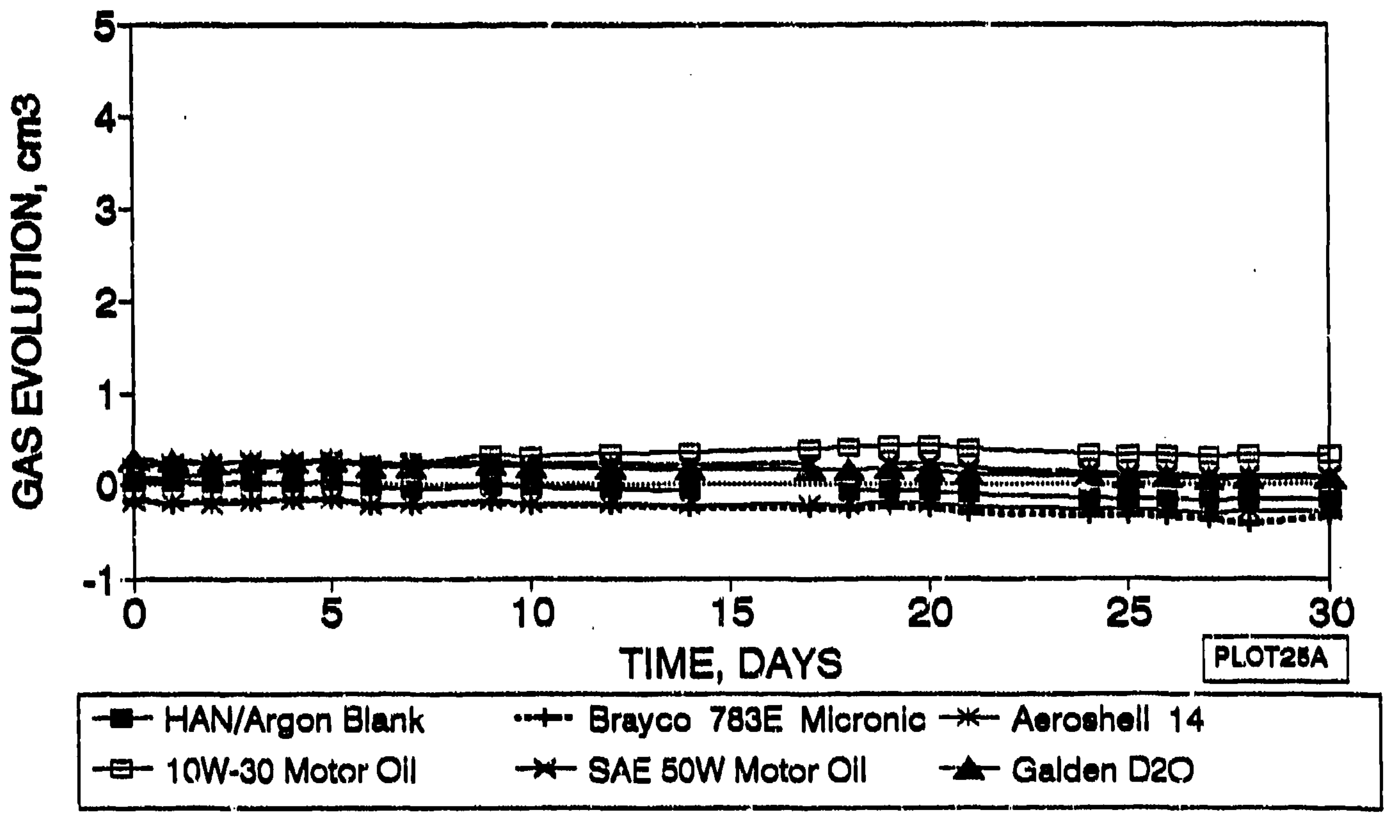


Figure 3.5: Compatibility of Materials in 60.8% HAN at 298 K (25°C)

Figures 3.1 through 3.5 present the gas evolution at 25°C. As can be seen, most samples did not produce much gas. The only samples found to be incompatible at 25°C were Al-6061, Aeroshell 17 and Silver Solder MG120. The graphs are arranged such that each graph carries a gas evolution trace for the control (blank) that was run along in the same group of 25 ampules. The blank trace is always the first trace listed and the graph symbol for the blank is always the solid square (---■----). On the same graph are then four to five samples, such that no more than six curves are shown on the same graph. If more than six curves were shown on the same graph, the graph would get too "busy" and it would be difficult to trace individual curves because many of them may fall on top of each other. In spite of tracing no more than six curves in a single graph, in some of the graphs the curves do still fall on top of each other simply because there was not much activity and the curves of the materials specimens are not much different from those of the blank. This "problem" (actually, a non-problem) is only observed in the 25°C series. For the 65°C series, the curves diverge sufficiently such that they do not fall on top of each other. The 65°C curves are therefore better suited to illustrate the method of data reduction because the curves are more differentiated from each other.

The vertical scale expansion of the graphs was chosen such that it can accommodate the maximum gas evolution of the most incompatible samples, yet show enough detail of the compatible samples. Although the apparatus can handle gas evolution up to near 20 cm^3, the maximum ordinate scale was chosen at 5 cm^3 for 25°C tests and 10 cm^3 for 65°C tests, which is a good compromise. Likewise, the optimum ordinate scale extension for the *normalized* gas evolution was 1.0 or 2.0 cm^3/cm^2 for the 65 °C series of tests.

Although the ampules with 300 mm Hg travel of the U-tube manometers were capable of recording the formation of a total of 20 cm^3 gas (at standard temperature and pressure = STP), none of the gas volume evolution tables or charts shows this large an amount of gas formed. The samples tested were either grossly incompatible and the full scale range of the manometer was exceeded within less than three days at 338K (65°C) (Samples Al-6061 and Silver Solder MG 120), or the gas evolution within 30 days stayed below 5 cm^3 STP. Therefore the gas volume graphs use 5 or 10 cm^3 as an expanded scale in order to provide a good scale expansion at which differences in gas evolution become discernible. If the full scale of 20 cm^3 had been used as the ordinate scale on all graphs, the pressure (volume) traces would all fall on top of each other.

The sample gas volume curves are identified by graph symbols in the legend at the bottom of each graph. The sample names are sometimes truncated because in the case of long sample names not all letters would fit into the legend box. There are sufficient letters shown to allow the unique identification of each sample. The sequence of samples is the same as that used in most other tables in this report (by Government supplied sample number, not shown on graphs).

The 25°C tests served essentially as a screening test for the subsequent 65°C tests to assure that none of the samples would react violently and endanger the adjacent samples when it cooked off.

Most of the first batch of 25 samples at 298 K (25°C) showed a slow pressure decrease during 30 days as the result of continuing loss of dissolved helium that could not be replaced by purging with argon. Table 3.4 shows a method how this unwanted drift of the baseline can be eliminated by adding the same amount of gas as was lost from the control to all other specimens (assuming they all contained the same amount of helium contamination at the beginning of the test). After this correction, all gas evolution numbers are positive, although most samples except Al-6061 had only a very slow rate of gas evolution at 298 K.

The second batch of samples at 25°C included mostly nonmetallic samples and lubricants. There were only two samples that showed higher than normal gas evolution rates, Sample 158 (Aeroshell 17 Grease), and Sample 311A, MG 120 Silver Solder. There was moderate gas evolution with a sample of SAE 10W-30 Motor Oil. The tests with the other samples in the second batch at 25°C were uneventful.

Table 3.5 gives a summary of the same data, in which the samples were arranged and sorted by the rate of gas evolution. The worst cases with the highest rates of gas evolution are shown first. None of the samples tested at 298 K reacted vigorously enough that would have precluded their testing at 338 K.

3.2.2.2 Comments on Data Reduction

The raw data were not processed through a Statistical Analysis System computer program which would tend to smooth the curves. The up-and-down fluctuations in ampule pressure visible in Figures 3.1 through 3.5 are mostly caused by barometric pressure fluctuations. Although the barometer is read daily and corrections for barometric pressure are entered into the data reduction routine on a spread sheet, there appears to be some hysteresis where the indicated ampule pressure does not immediately adjust to changes in ambient pressure. Extensive Pacific Ocean weather fronts moving through the area and the accompanying change in barometric pressure were immediately reflected in the shape of the pressure curves. Toward the end of the testing, when mercury tended to stick to the glass walls, the operator used a clean glass rod to agitate the mercury column to form a nice round meniscus which could be accurately read with the cathetometer independently of the direction in which the mercury had last traveled. This improved the smoothness of the pressure traces. The stirring of the mercury for achieving a clean meniscus was particularly necessary where some black mercury sulfide had formed from interaction with the decomposition gases (Samples 412B and 402B. See Par. 3.2.5).

It is recommended to conduct future long-term compatibility testing in hermetically closed all-glass flasks where pressure measurements can be taken unaffected by ambient barometric pressure fluctuations.

Table 3.4: Gas Evolution at 298 K (25°C)

Speci-men No.	TRADE NAME	FINAL VOLUME cm^3	CORRECTED FOR He LEAK cm^3	RATE OF GAS EVOLUT[ION] cm^3/da[y]
From first batch at 25 oC				
73	CRES-301	-0.24	0.06	0.002
74	CRES-304	-0.04	0.26	0.009
75	17-7PH (Mill annnealed)	-0.16	0.14	0.005
112	Haynes Alloy 255	-0.28	0.02	0.001
113	Ferralium Alloy 255	-0.06	0.24	0.008
120	Tristelle Alloy T5-2	-0.24	0.06	0.002
134	Stellite #8 on 17-4PH	-0.16	0.14	0.005
135	Stellite #6 on Nicraly on 17-4	-0.04	0.26	0.009
145	Silicon carbide PS-9242	-0.19	0.10	0.003
162A	UCAR LW-15 on 17-4	-0.10	0.20	0.007
163A	UCAR LC-1H on 17-4	-0.09	0.21	0.007
165A	Molydag on 17-4 PH	-0.17	0.12	0.004
166A	Nitrided Tribocor 532N	-0.37	-0.08	-0.003
179A	Ag Plate on 17-4 PH	-0.16	0.13	0.004
220A	Sermatech GC-WC-111 on 17-4 PH	-0.18	0.11	0.004
258A	Tantalum coating	-0.34	-0.04	-0.001
263A	CRES-316	-0.04	0.25	0.008
266A	Tungsten weld rod	0.01	0.31	0.010
268A	CRES-302	-0.21	0.09	0.003
269A	CRES-308	-0.38	-0.08	-0.003
306A	15-5 PH	-0.36	-0.06	-0.002
310A	Nickel flash on 17-4 PH	-0.22	0.08	0.003
326A	Al-6061	8.94	9.24	0.308
351A	Steel MP35N	-0.19	0.10	0.003
B1	Empty ampule	0.05	0.35	0.012
0	Blank 1	-0.30	0.00	0.000

TABLE 3.4 (continued) Gas Evolution at 298K (25*C)

Spec. No.	TRADE NAME	FINAL VOLUME cm^3	RATE cm^3/day
From second batch at 25 oC			
2A	Tefzel lining	-0.3	-0.009
3A	Kynar lining	-0.4	-0.013
5A	Carbon bearing	-0.2	-0.007
6A	Ceramic thrust washer	0.0	0.001
7A	Superproline	-0.4	-0.015
17A	Zirconium Zr-702	-0.3	-0.010
18A	Zirconium Zr-705	-0.1	-0.003
19A	Silicon carbide	-0.3	-0.009
116	Graphitar Grade 47	-0.1	-0.003
126A	Grease 3451	-0.1	-0.004
129A	Victrex 4800G	-0.5	-0.016
130A	Victrex Gr. 4101GL20	-0.4	-0.013
146A	Arlon 1160	-0.4	-0.012
147A	Arlon 1260	-0.3	-0.009
156A	Paxon BA 50-100	-0.3	-0.011
158A	Aeroshell 17	2.3	0.076
161A	Rulon II	-0.3	-0.010
259A	Polyvinylchloride tubing	-0.3	-0.010
311A	MG 120 Silver solder	2.7	0.091
335A	Brayco 783E Micronic	-0.4	-0.012
396A	Aeroshell 14	-0.3	-0.009
402A	10W-30 Motor Oil	0.3	0.011
412A	SAE 50W Motor Oil	0.1	0.004
446A	Galden D20	0.1	0.002
HB2	HAN\Argon Blank	-0.2	-0.005
Air	Air Blank	-0.2	-0.008
Ar2	Argon Blank	0.1	0.002

Table 3.5: Gas Evolution Rate at 298 K (25°C); In Order of Decreasing Gas Evolution

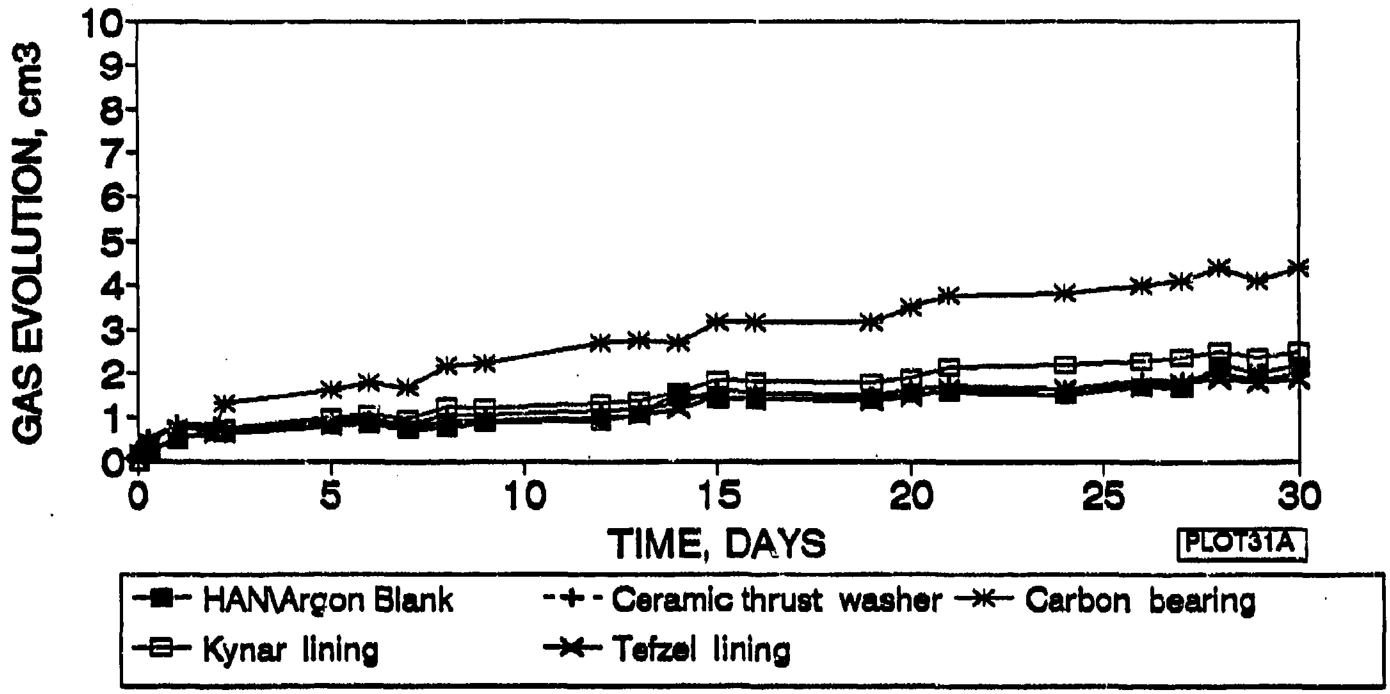
Note: 20 Worst Materials Listed Only

Spec. No.	TRADE NAME Sample Designation	Gas Volume, cm^3	Gas Evolution Rate cm^3/day
326A	Al-6061	9.2	0.308
311A	MG 120 Silver solder	2.7	0.091
158A	Aeroshell 17	2.3	0.076
402A	10W-30 Motor Oil	0.3	0.011
266A	Tungsten weld rod	0.3	0.010
74	CRES-304	0.3	0.009
135	Stellite #6 on Nicraly on 17-4	0.3	0.009
263A	CRES-316	0.2	0.008
113	Ferralium Alloy 255	0.2	0.008
163A	UCAR LC-1H on 17-4	0.2	0.007
162A	UCAR LW-15 on 17-4	0.2	0.007
134	Stellite #8 on 17-4PH	0.1	0.005
75	17-7PH (Mill annnealed)	0.1	0.005
179A	Ag Plate on 17-4 PH	0.1	0.004
165A	Molydag on 17-4 PH	0.1	0.004
220A	Sermatech GC-WC-111 on 17-4 PH	0.1	0.004
412A	SAE 50W Motor Oil	0.1	0.004
351A	Steel MP35N	0.1	0.003
145	Silicon carbide PS-9242	0.1	0.003
268A	CRES-302	0.1	0.003
310A	Nickel flash on 17-4 PH	0.1	0.003

3.2.2.3 Gas Evolution at 338 K (65°C)

The testing at 65°C resulted in some more interesting gas evolution charts. For this reason, the charts are presented here in both formats, as plain gas evolution (Gas volume reduced to STP conditions (273 K, 101 kPa). The ordinate scale unit of these graphs is cm^3.) as well as normalized gas evolution (Gas volume reduced to STP conditions (273 K, 101 kPa) and divided by the surface area of the specimen. The ordinate scale unit of these graphs is cm^3/cm^2.).

The graphs are arranged such that the simple gas evolution curve graph ("PLOT_A") is on the top of the page and the *normalized* gas evolution graph ("PLOT_B") is at the bottom of the page. If the user wants to compare gas evolution of one given material to the gas evolution in the control (blank) under the conditions of the experiment, one would look at the volume curves at the top of the pages (PLOT_A). It one wants to compare different materials with different shapes and surface areas, the curves at the bottom of the page should be used (PLOT_B). As can be seen in Figures 3.6 through 3.15, there was substantially more gas evolution in the 338 K (65°C) tests than in the 298 K (25°C) tests. This was to be expected.



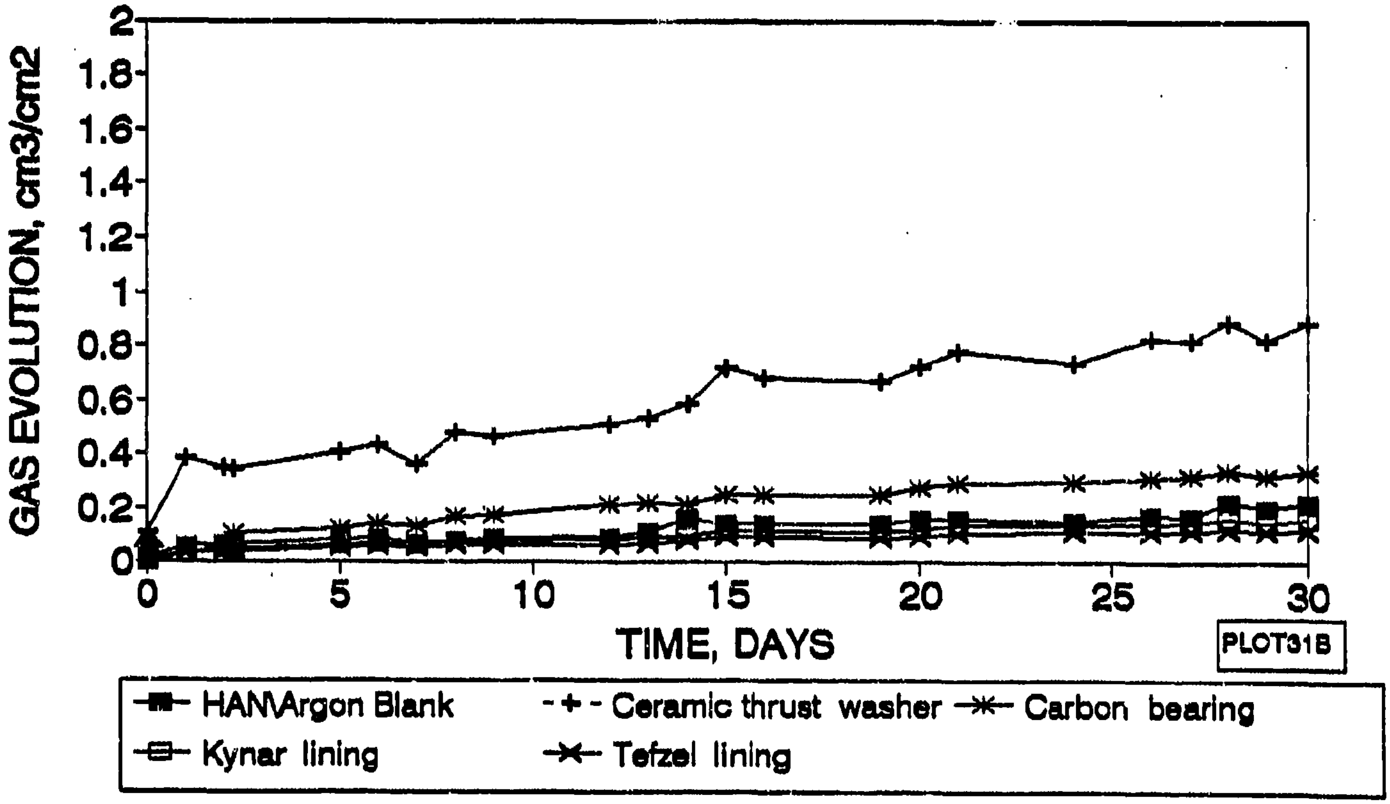
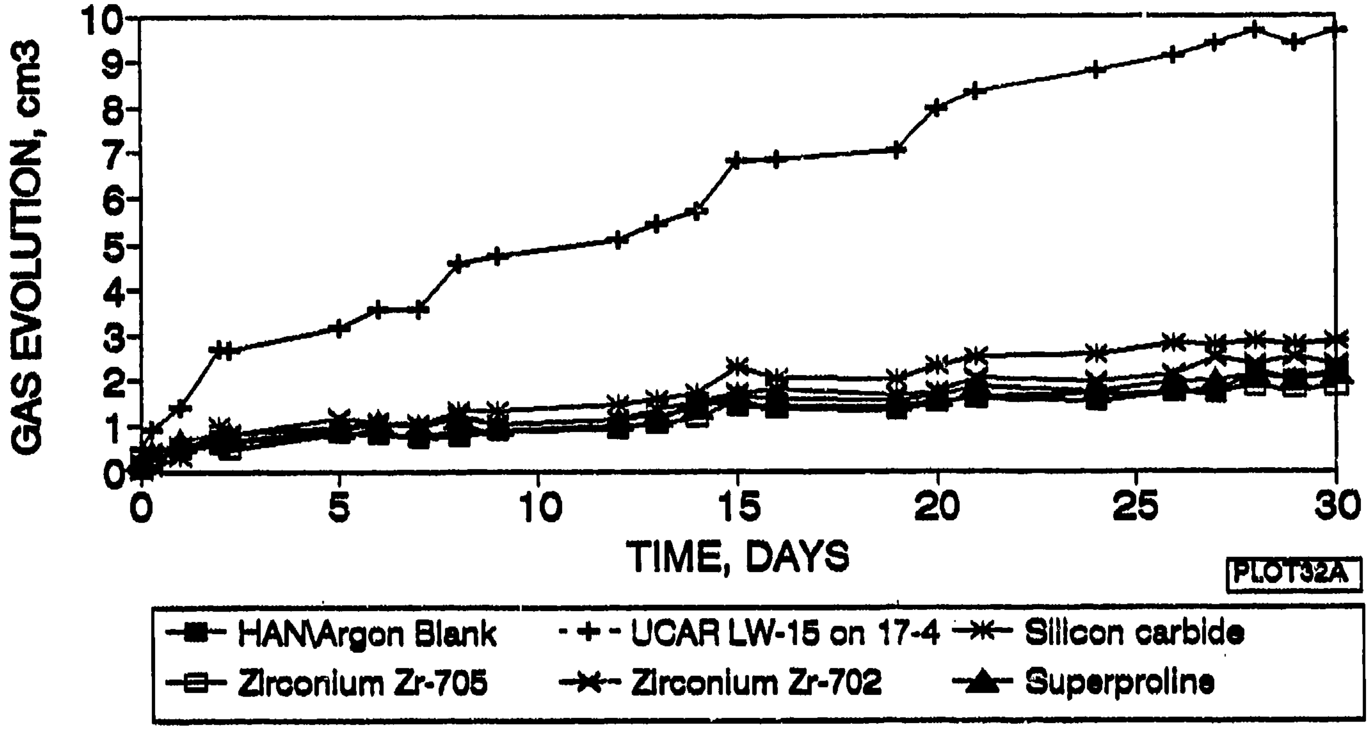


Figure 3.6: Compatibility of Materials in 60.8% HAN at 338 K (65°C)



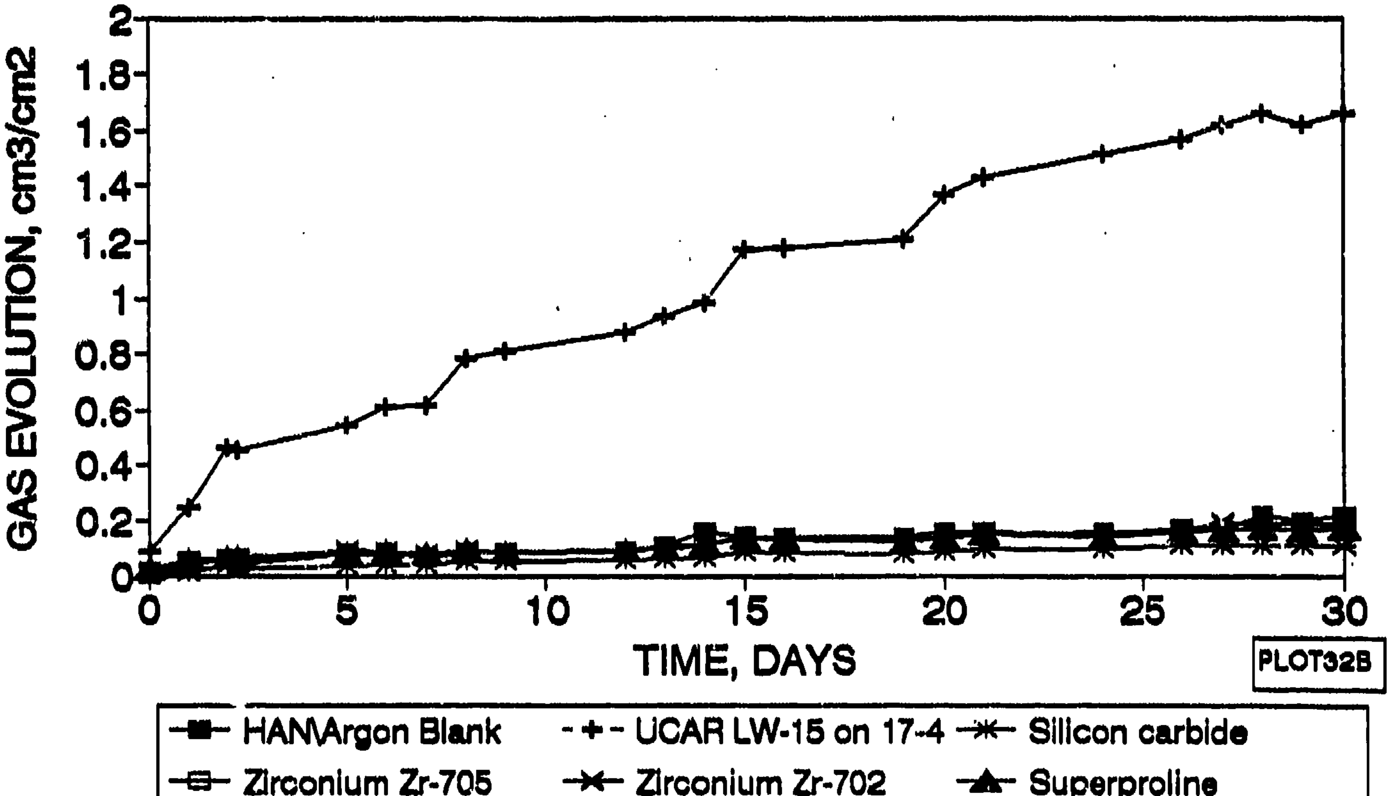
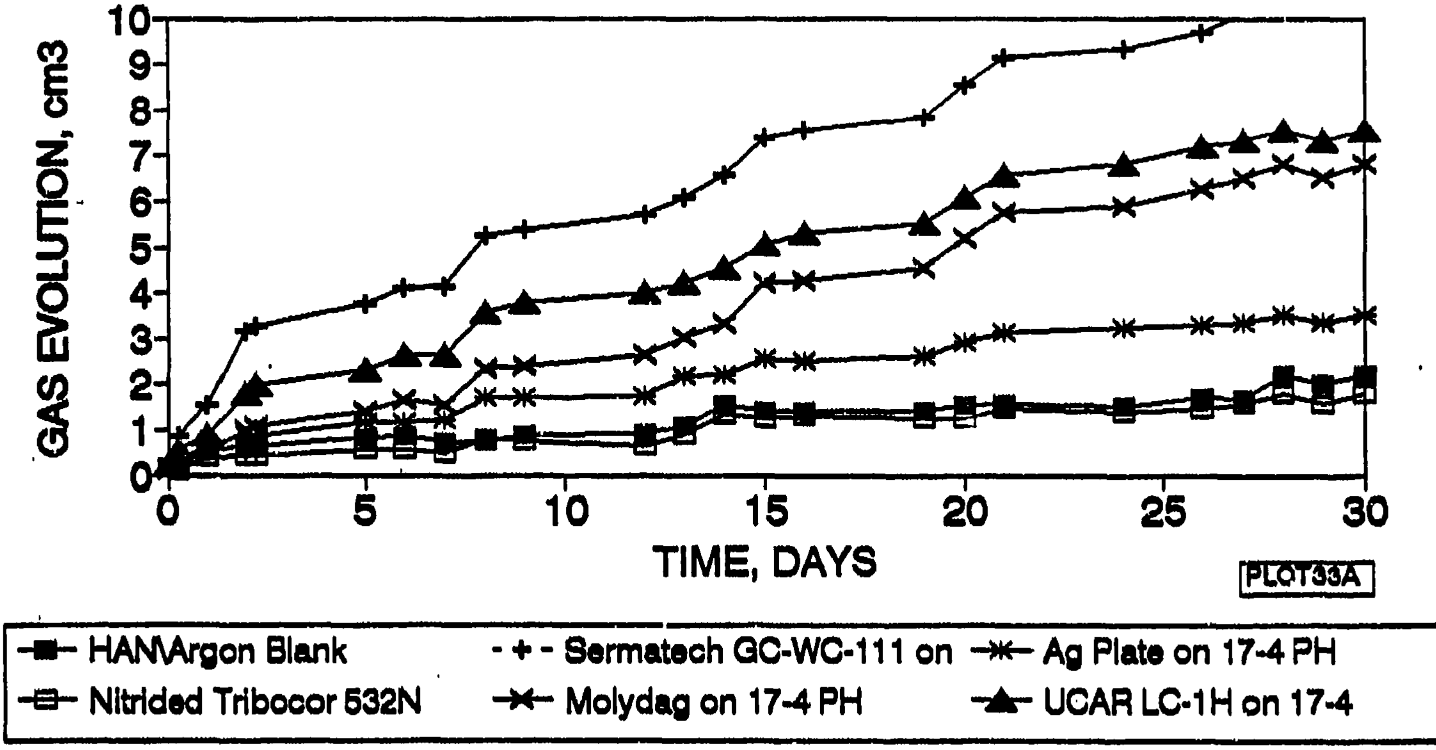


Figure 3.7: Compatibility of Materials in 60.8% HAN at 338 K (65°C)



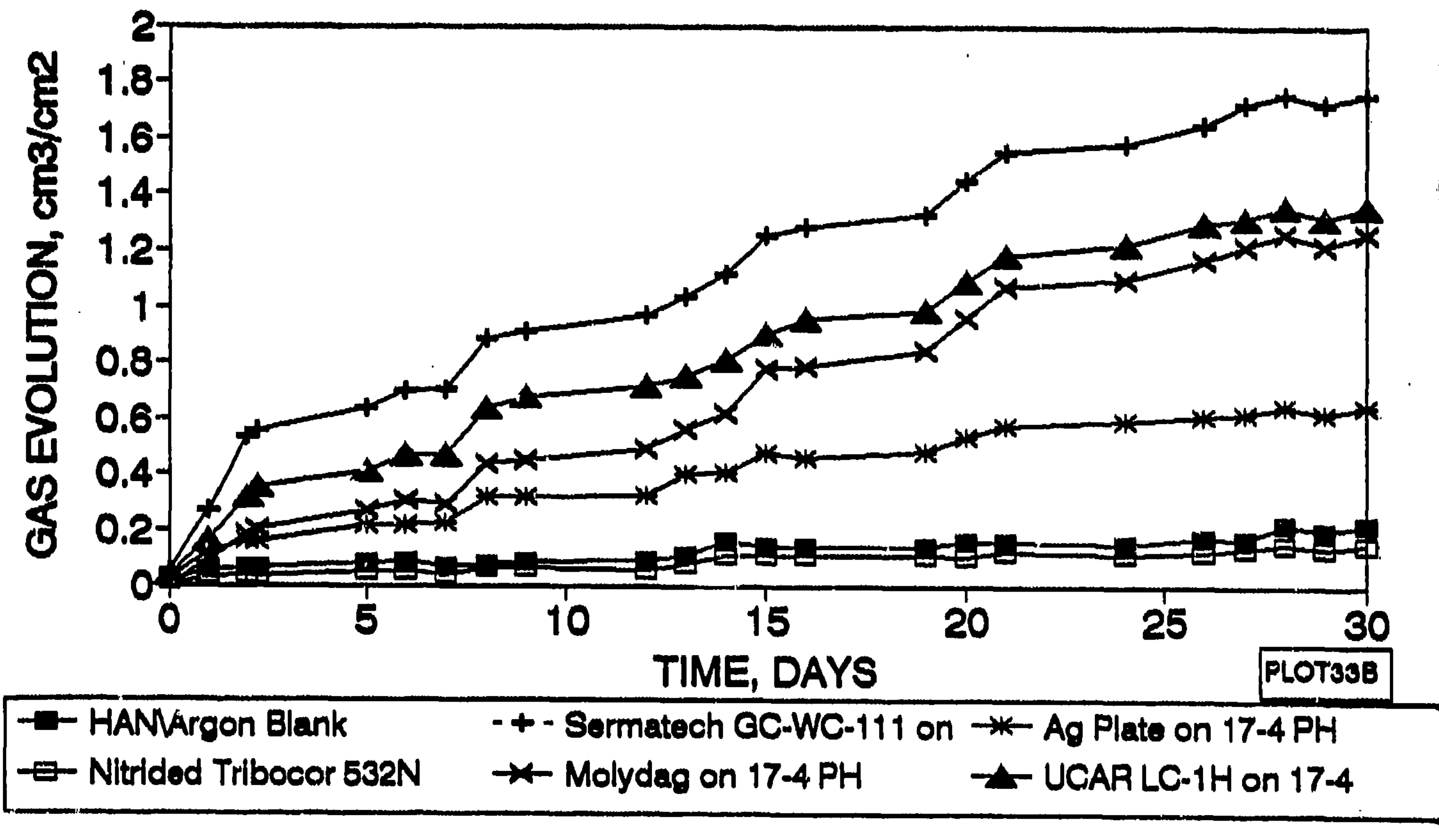
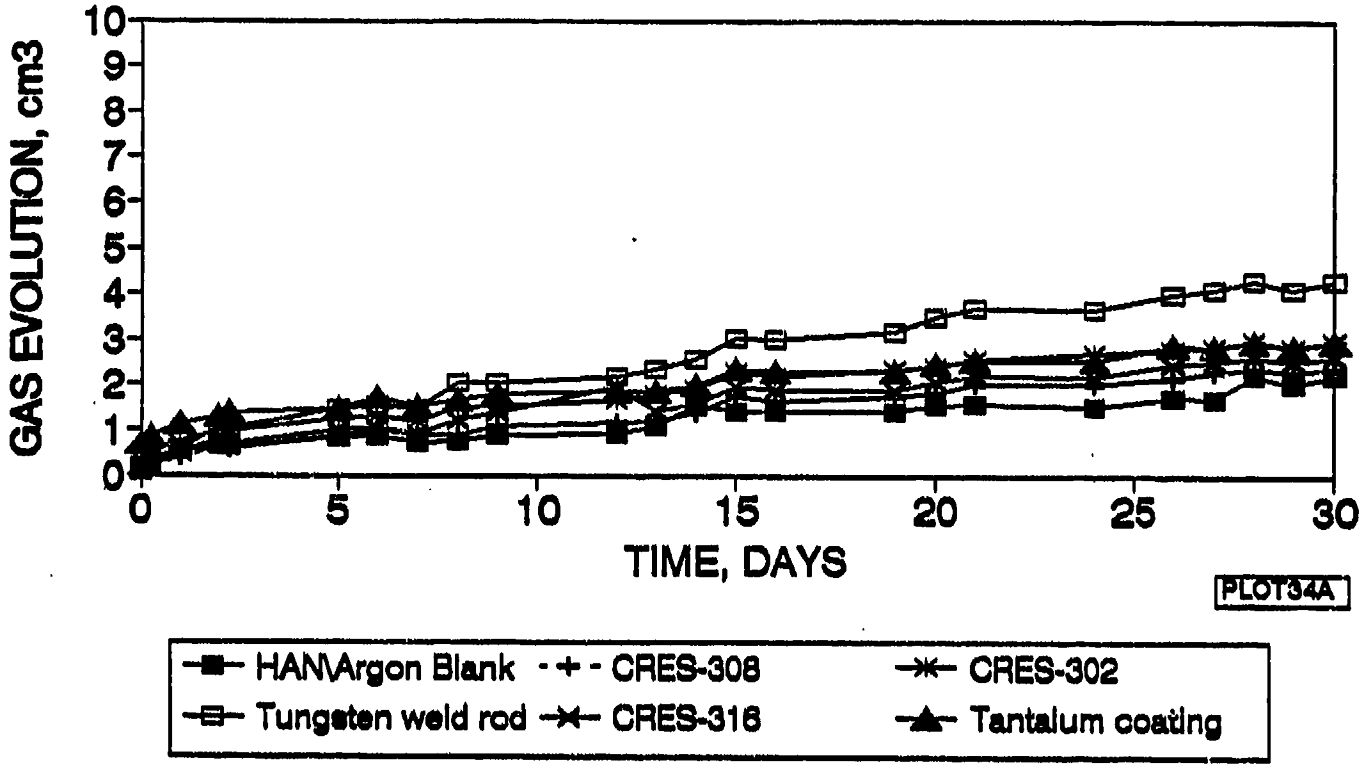


Figure 3.8: Compatibility of Materials in 60.8% HAN at 338 K (65°C)



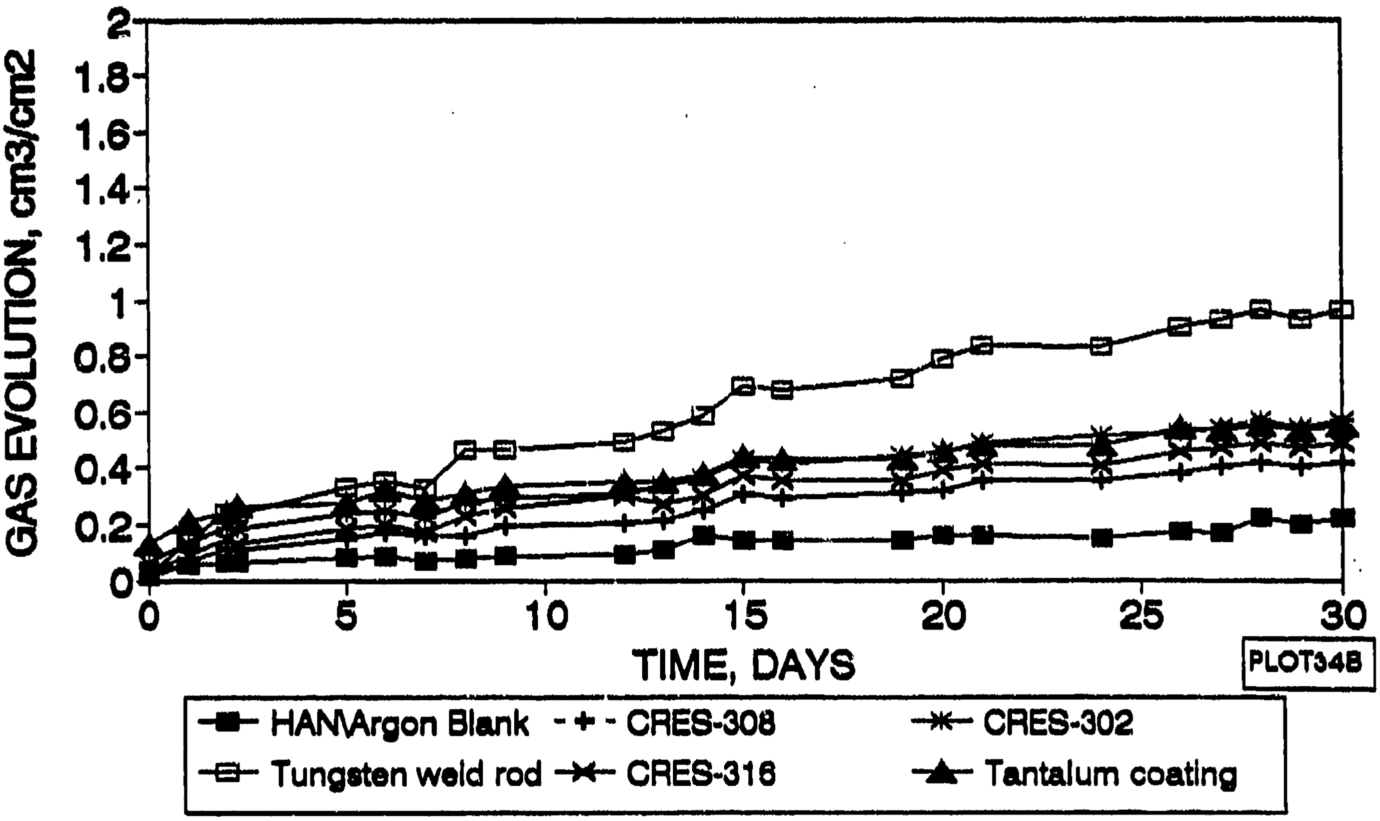


Figure 3.9: Compatibility of Materials in 60.8% HAN at 338 K (65°C)

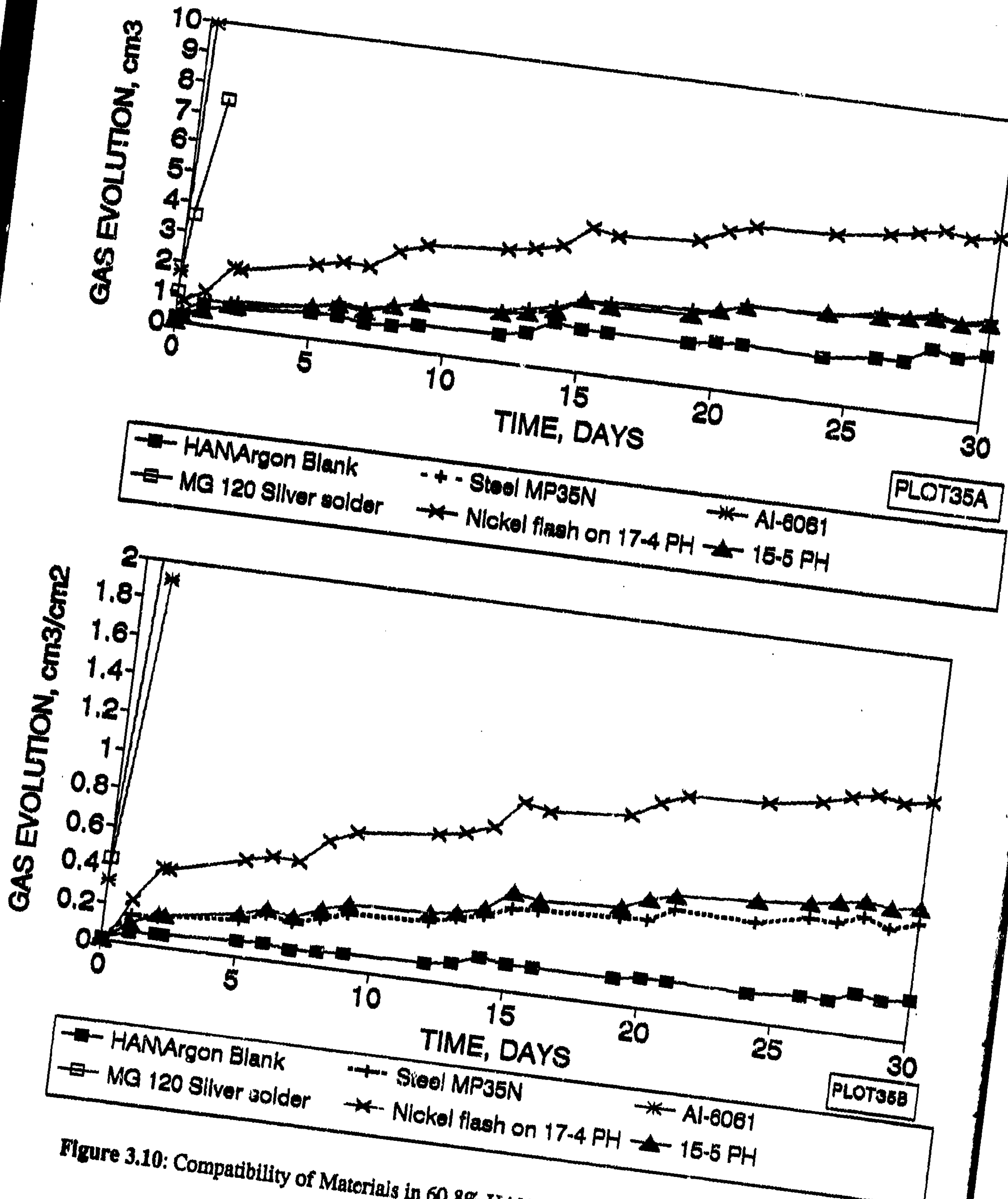
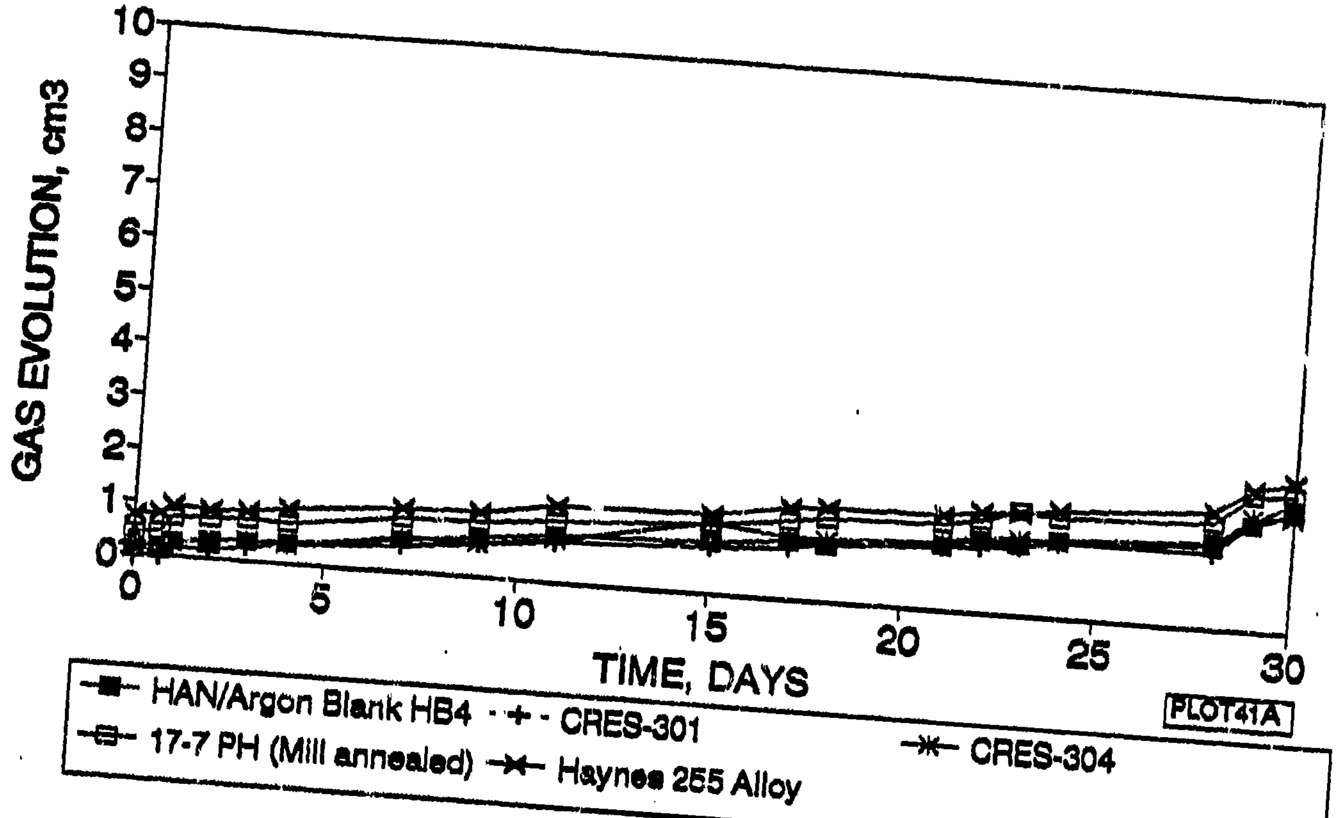


Figure 3.10: Compatibility of Materials in 60.8% HAN at 338 K (65°C)



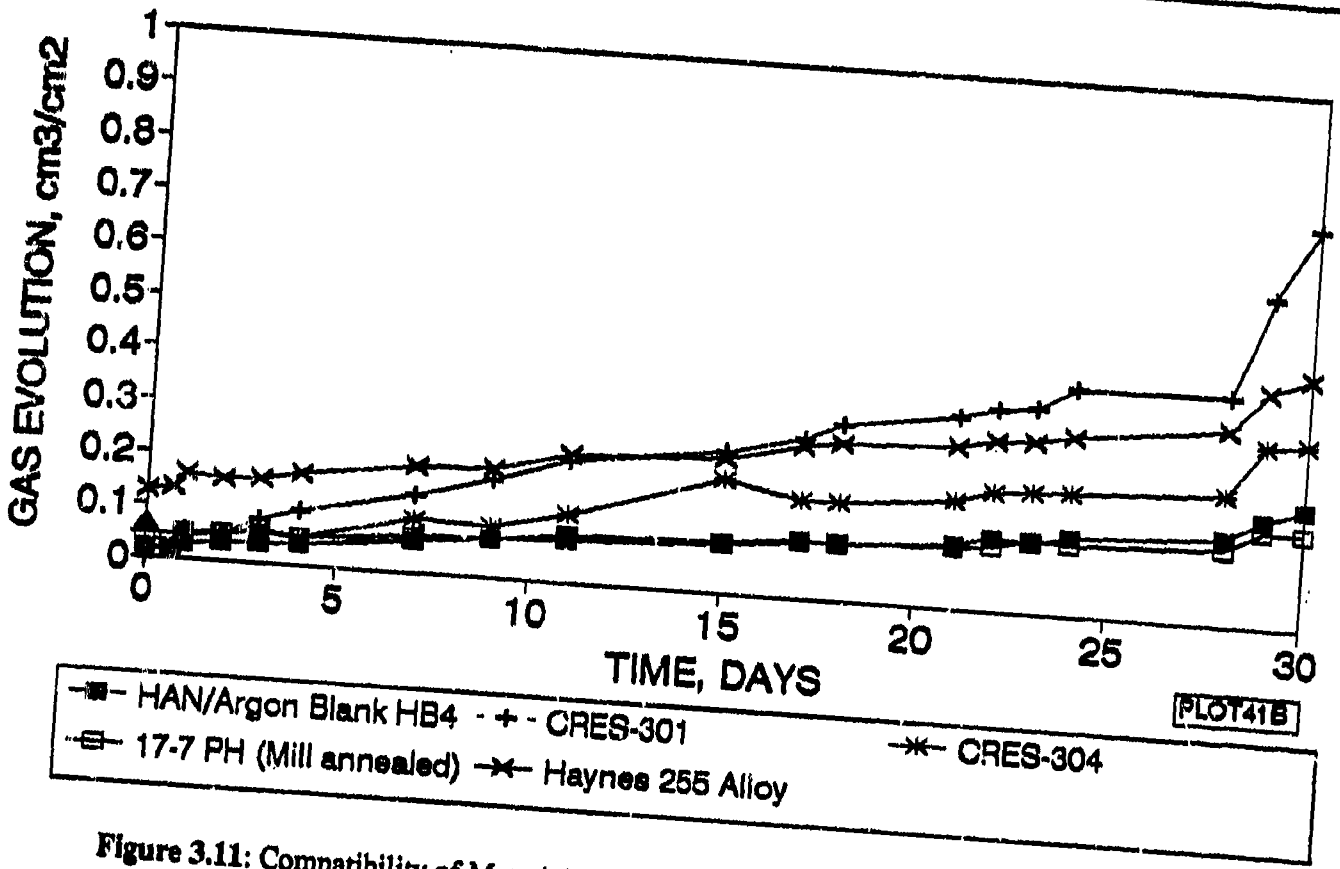
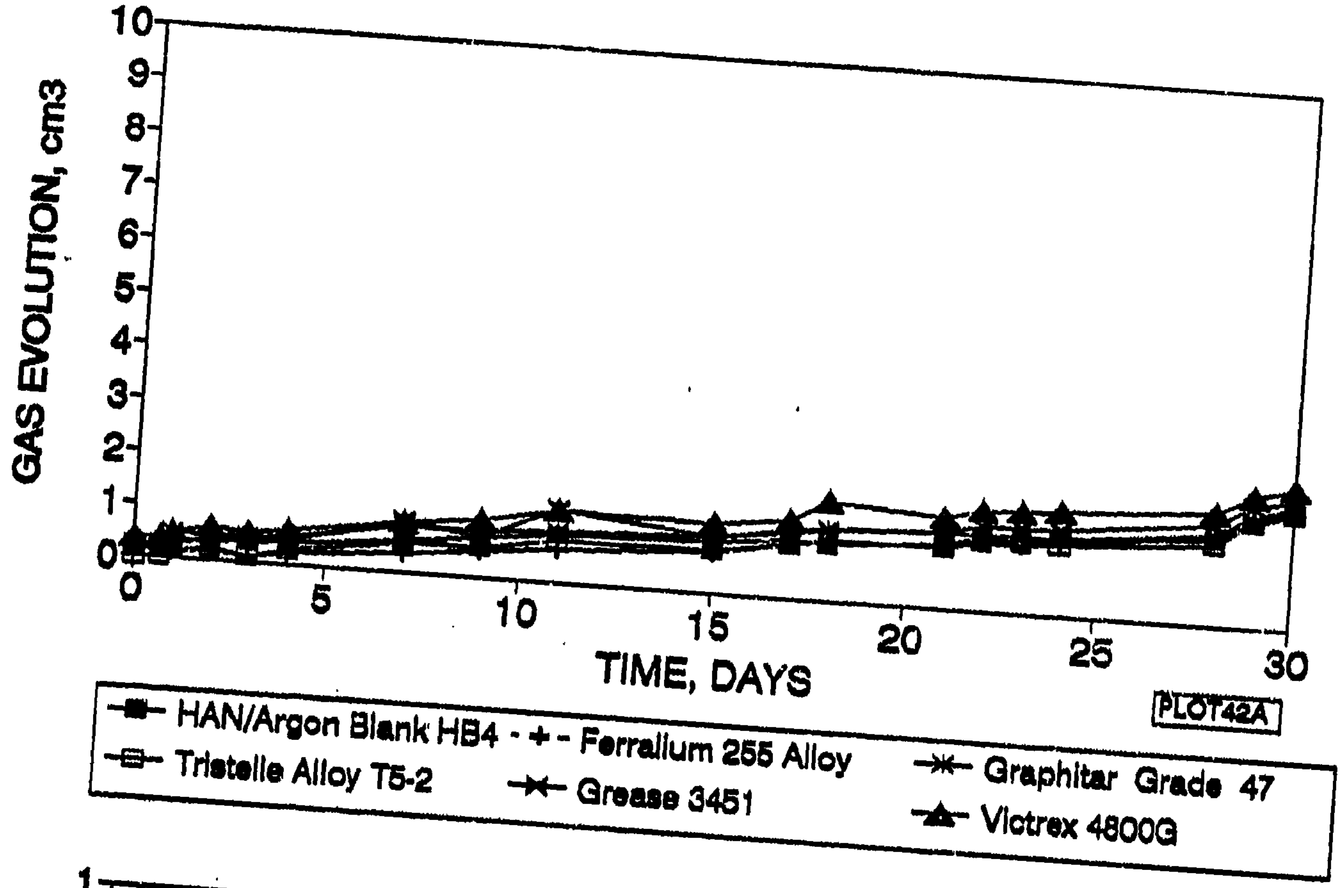


Figure 3.11: Compatibility of Materials in 60.8% HAN at 338 K (65°C)



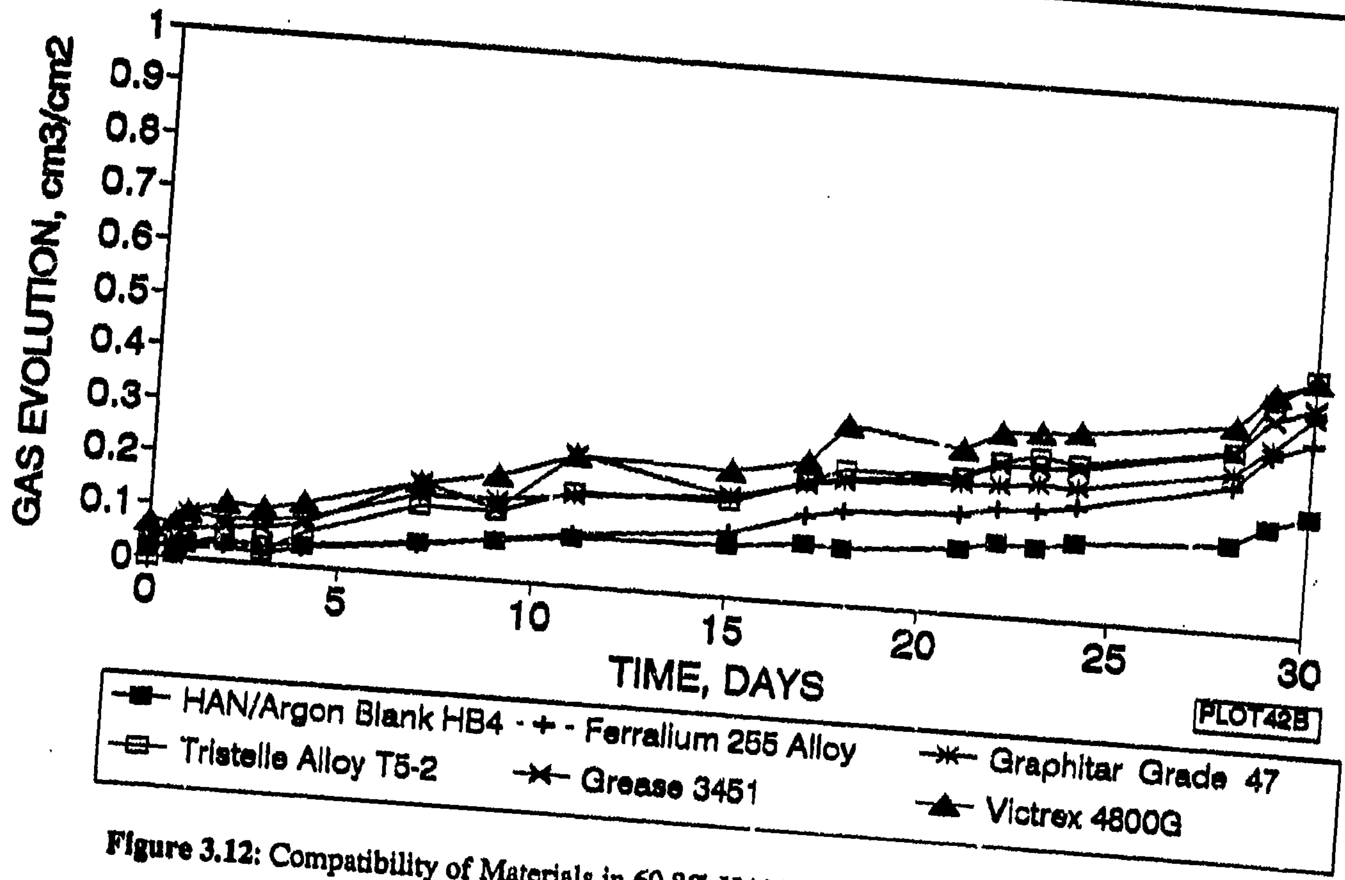
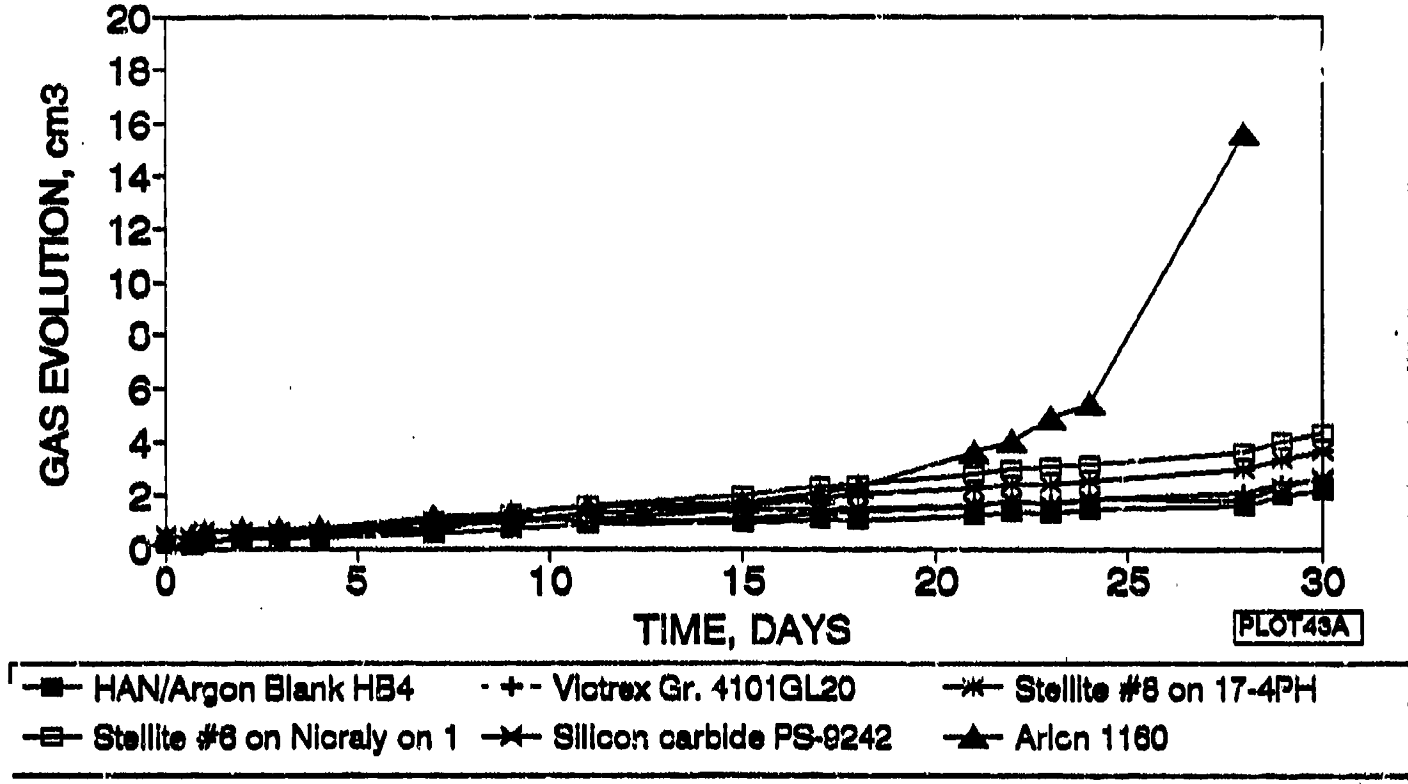


Figure 3.12: Compatibility of Materials in 60.8% HAN at 338 K (65°C)



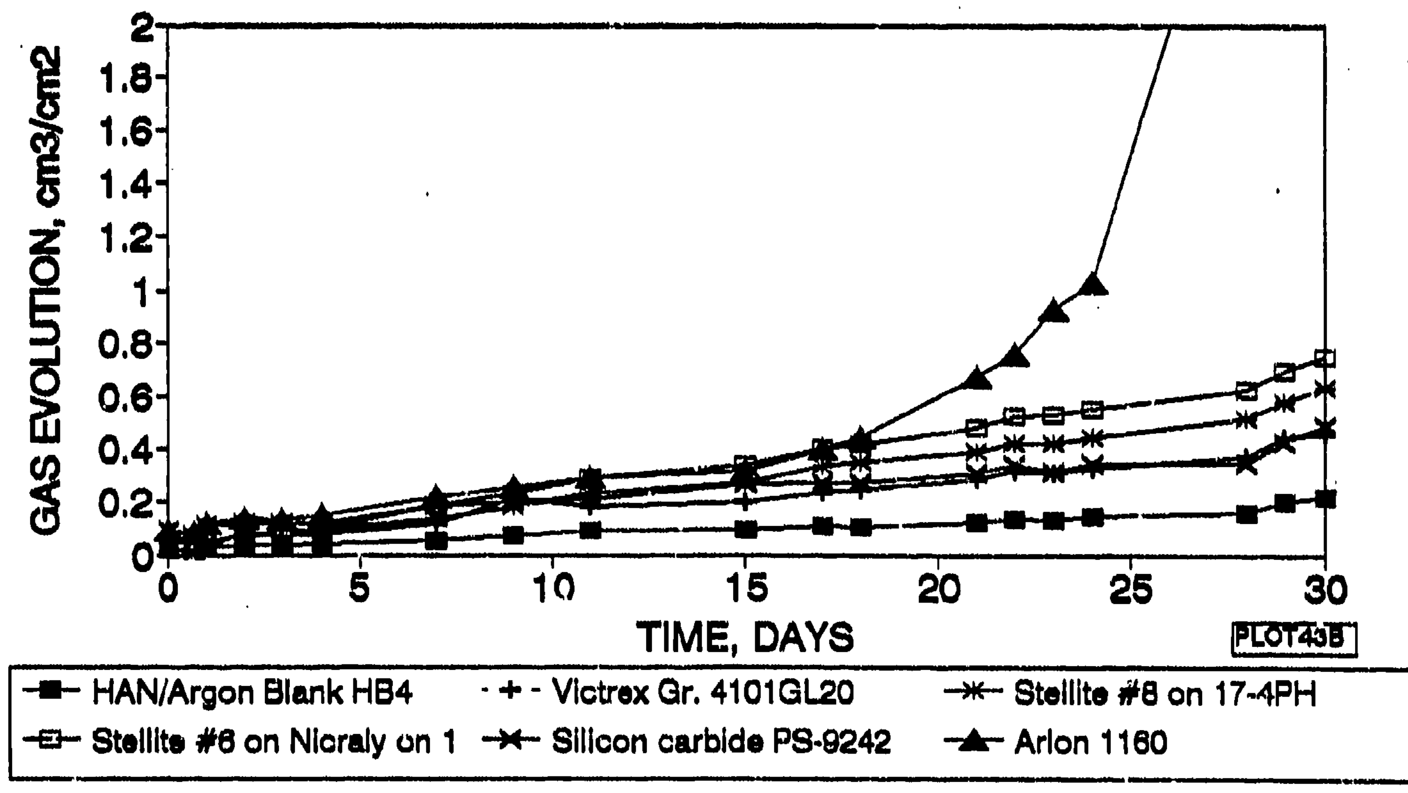


Figure 3.13: Compatibility of Materials in 60.8% HAN at 338 K (65°C)

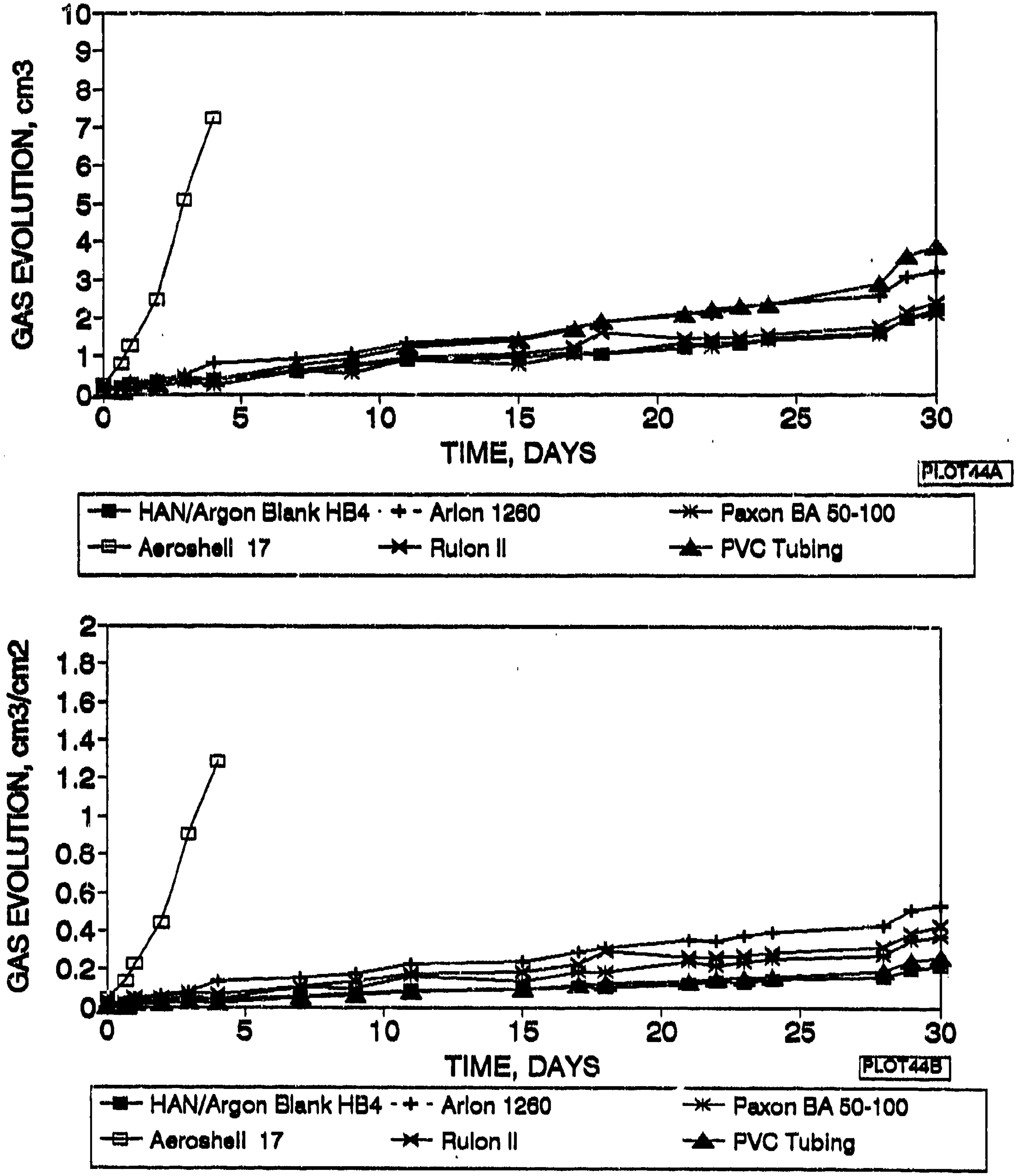
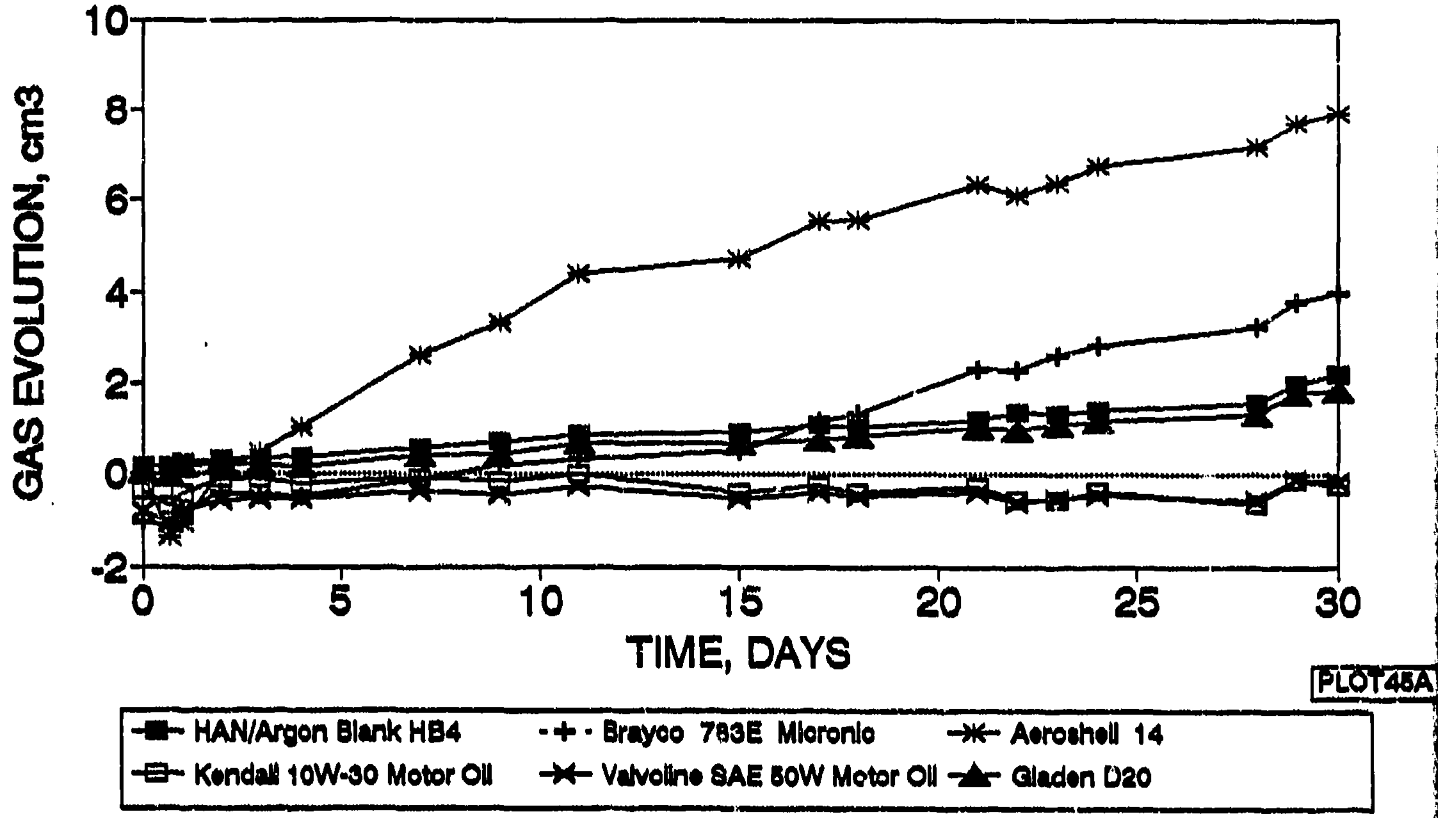


Figure 3.14: Compatibility of Materials in 60.8% HAN at 338 K (65°C)



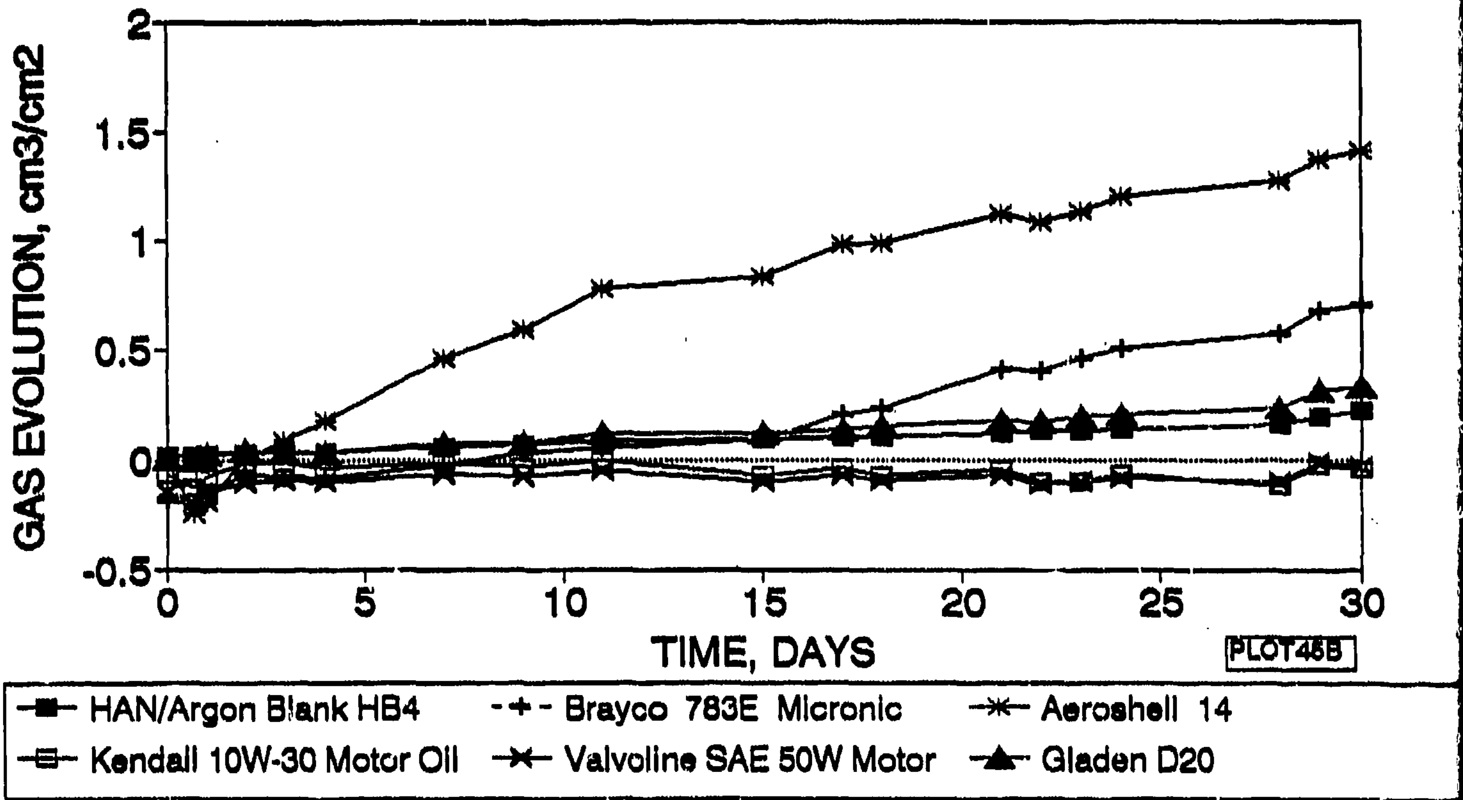


Figure 3.15: Compatibility of Materials in 60.8% HAN at 338 K (65°C)

There were three samples that exceeded the capability of the mercury U-gauge within three days, aluminum 6061 and silver solder MG120 (Figure 3.10) and Aeroshell 17 (Figure 3.14). In addition, one case of accelerating rate of gas evolution was observed with Arlon 1160 (solid triangle symbols in Figure 3.13).

The ultimate amount of gas evolved is tabulated in Tables 3.6 and 3.7. Table 3.6 gives the gas volumes in the same sequence as the samples are listed in all other tables and on the graphs. Table 3.7 presents the data of the 21 worst materials sorted in order of decreasing gas evolution, highlighting the most incompatible samples first that should be avoided for further construction of liquid propellant guns.

Table 3.6: Gas Evolution at 338 K (65°C)

Spec. No.	TRADE NAME	MAX. VOL.	DAYS	RATE cm^3/DAY
2B	Tefzel lining	1.9	30	0.06
3B	Kynar lining	2.5	30	0.08
5B	Carbon bearing	4.4	30	0.15
6B	Ceramic thrust washer	2.0	30	0.07
7B	Superproline	2.1	30	0.07
17B	Zirconium Zr-702	2.3	30	0.08
18B	Zirconium Zr-705	1.8	30	0.06
19B	Silicon carbide	2.9	30	0.10
162B	UCAR LW-15 on 17-4	9.7	30	0.32
163B	UCAR LC-1H on 17-4	7.6	30	0.25
165B	Molydag on 17-4 PH	6.8	30	0.23
166B	Nitrided Tribocor 532N	1.8	30	0.06
179B	Ag Plate on 17-4 PH	3.5	30	0.12
220B	Sermatech GC-WC-111 on 17-4 PH	10.3	30	0.34
258B	Tantalum coating	2.9	30	0.10
263B	CRES-316	2.6	30	0.09
266B	Tungsten weld rod	4.3	30	0.14
268B	CRES-302	3.0	30	0.10
269B	CRES-308	2.4	30	0.08
306B	15-5 PH	3.2	30	0.11
310B	Nickel flash on 17-4 PH	6.1	30	0.20
311B	MG 120 Silver solder	7.5	1	7.50
326B	Al-6061	9.9	0.5	19.80
351B	Steel MP35N	3.4	30	0.11
HB3	HAN\Argon Blank	2.2	30	0.07

Table 3.6 (continued)

Spec. No.	TRADE NAME	VOLUME cm3, STP	DAYS	RATE, cm^3/day
73B	CRES-301	2.4	30	0.08
74B	CRES-304	2.1	30	0.07
75B	17-7 PH (Mill annealed)	2.5	30	0.08
112B	Haynes 255 Alloy	2.8	30	0.09
113B	Ferralium 255 Alloy	2.3	30	0.08
116B	Graphitar Grade 47	2.3	30	0.08
120B	Tristelle Alloy T5-2	2.2	30	0.07
126B	Grease 3451	2.4	30	0.08
129B	Victrex 4800G	2.6	30	0.09
130B	Victrex Gr. 4101GL20	2.6	30	0.09
134B	Stellite #8 on 17-4PH	3.7	30	0.12
135B	Stellite #6 on Nicraly on 17-4	4.3	30	0.14
145B	Silicon carbide PS-9242	2.6	30	0.09
146B	Arlon 1160	15.6	28	0.56
147B	Arlon 1260	3.2	30	0.11
156B	Paxon BA 50-100	2.1	30	0.07
158B	Aeroshell 17	4.2	4	1.05
161B	Rulon II	2.4	30	0.08
259B	PVC Tubing	3.9	30	0.13
335B	Brayco 783E Micronic	4.0	30	0.13
396B	Aeroshell 14	7.9	30	0.26
402B	Kendall 10W-30 Motor Oil	-0.2	30	-0.01
412B	Valvol[illegible] SAE 50W Motor Oil	-0.2	30	-0.01
446B	Glade[illegible] D20	1.9	30	[illegible]
HB4	HAN\Argon Blank	2.2	30	[illegible]

Table 3.7: Gas Evolution at 65°C; In Order of Decreasing Gas Evolution Rate

Note: Only 27 worst samples listed here. The worst samples are on top of the table.

Specimen No.	TRADE NAME	VOLUME cm3, STP	DAYS	RATE, cm3/day
326B	Al-6061	9.9	0.5	19.80
311B	MG 120 Silver solder	7.5	1	7.50
158B	Aeroshell 17	4.2	4	1.05
146B	Arlon 1160	15.6	28	0.56
220B	Sermatech GC-WC-111 on 17-4 PH	10.3	30	0.34
162B	UCAR LW-15 on 17-4	9.7	30	0.32
396B	Aeroshell 14	7.9	30	0.26
163B	UCAR LC-1H on 17-4	7.6	30	0.25
165B	Molydag on 17-4 PH	6.8	30	0.23
310B	Nickel flash on 17-4 PH	6.1	30	0.20
5B	Carbon bearing	4.4	30	0.15
135B	Stellite #6 on Nicraly on 17-4	4.3	30	0.14
266B	Tungsten weld rod	4.3	30	0.14
335B	Brayco 783E Micronic	4.0	30	0.13
259B	PVC Tubing	3.9	30	0.13
134B	Stellite #8 on 17-4PH	3.7	30	0.12
179B	Ag Plate on 17-4 PH	3.5	30	0.12
351B	Steel MP35N	3.4	30	0.11
147B	Arlon 1260	3.2	30	0.11
306B	15-5 PH	3.2	30	0.11
268B	CRES-302	3.0	30	0.10
258B	Tantalum coating	2.9	30	0.10
19B	Silicon carbide	2.9	30	0.10
112B	Haynes 255 Alloy	2.8	30	0.09
129B	Victrex 4800G	2.6	30	0.09
145B	Silicon carbide PS-9242	2.6	30	0.09
263B	CRES-316	2.6	30	0.09
130B	Victrex Gr. 4101GL20	2.6	30	0.09

It is of interest to compare the gas evolution rates of the control blanks in the current series of tests to gas evolution rate data reported by other investigators (Reference 17). As can be seen from the data in Table 3.8, the rate of gas evolution at 338 K (65°C) was somewhat higher in the current test, while the gas evolution rate at 298K (25°C) was too small to be measured in either study. This can be due to differences in experimental technique or in the purity of the raw material used for the tests. Also, passivation of the surface of the glass ampules by immersing them in HAN solution prior to the test should be considered. Although borosilicate glass in fairly resistant to acid attack, some materials may leach from the glass that will catalyze HAN decomposition. If the same ampules were used for a second time, the gas evolution rate might be lower.

Table 3.8: Gas Evolution Rates of HAN Blanks

Source of Data	Temperature, ^oC	Days	Gas Volume, cm^3 STP	Avg. Rate, cm^3/day
This study	25	30	<0.1	<0.004
This study	25	30	<0.1	<0.004
This study	65	30	2.2	0.07
This study	65	30	2.2	0.07
Reference 19	25	30	<0.30	<0.010
Reference 19	25	30	<0.30	<0.010
Reference 19	65	30	0.63	0.021
Reference 19	65	30	0.60	0.020

3.2.3 HAN Trace Metals Post-Test Results

Table 3.9 gives the AAS analysis results of HAN solutions off-loaded at the end of the test. As can be seen, substantial metal leaching has occurred with several of the coupons exposed. Not all off-loaded propellant samples were analyzed. With one exception, only HAN solutions removed from metals compatibility tests had to analyzed for metals. The materials selected were those where either gas evolution or discoloration of the solution had occurred. The one exception referred to above is that of a lubricant, Aeroshell 17 (Sample No. 158B) which caused high rates of gas evolution usually not expected from a pure hydrocarbon grease. AAS analysis showed that substantial amounts of molybdenum were leached from Aeroshell 17. It would be of interest to obtain the gross composition of this lubricant from the manufacturer to identify the incompatible additive, possibly molybdenum sulfide.

Table 3.9: Summary of Metals Analysis by Atomic Absorption

Spec. #	TRADE NAME	Al	Co	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Pb	Zn	Color Change
From first batch at 25 oC													
112	Haynes Alloy 255	<0.1	1.1	0.4	<0.08	0.4	0.2	0.1	<0.05	<0.05	0.7	0.2	Lt.pink-yellow
113	Ferralium Alloy 255	0.14	1.0	1.1	<0.08	1.5	0.3	0.15	<0.05	<0.05	0.7	0.2	Lt.pink-yellow
134	Stellite #8 on 17-4PH	<0.1	104	4.1	<0.08	4.4	0.3	0.3	0.25	5.7	0.7	0.2	Very slight pink
135	Stellite #6 on Nicr	6.9	109	5.4	0.3	4.6	0.2	0.35	0.18	33	0.75	0.2	Very slight pink
326A	Al-6061	530	1.3	2.9	0.4	3.5	2.7	0.5	0.3	0.03	1	0.4	None
From second batch at 25 oC													
311A	MG 120 Silver solder	<0.1	1.25	1.7	<0.08	0.3	0.25	0.3	0.3	<0.05	1.4	0.2	Turbid solution
From first batch at 65 oC													
263B	CRES-316				0.13	1.18				0.2			None
268B	CRES-302			0.23	0.15	1.18				0.23			None
269B	CRES-308				0.15	1.15		0.13		0.23			None
306B	15-5 PH			0.2	0.13	2.25							None
311B	MG 120 Silver solder	<0.2	1.2	2.5	<0.20	<0.13	0.3	0.3	<0.13	<0.13	2.2	0.1	White precppt.
326B	Al-6061	655	1.4	3.8	0.3	0.08	3.5	0.7	0.08	0.08	0.9	0.4	None
From second batch at 65 oC													
73B	CRES-301*		0.18	0.13	0.08	0.18		<0.03	<0.38	0.23			None
74B	CRES-304*		0.28	0.15	0.08	0.18		0.05	<0.38	0.23			None
75B	17-7 PH (Mill annealed)*		0.3	0.13	0.05	0.08		<0.03	<0.38	0.18			None
112B	Haynes Alloy 255*		0.38	0.18	0.03	0.05		<0.03	<0.38	0.2			None
113B	Ferralium Alloy 255*		0.3	0.13	0.03	0.15		<0.03	<0.38	0.13			None
158B	Aeroshell 17		0.25	0.15	<0.03	0.98		<0.03	2.9	0.2			Light red
HB4	HAN\Argon Blank		0.33	0.13	0.08	0.13		0.03	<0.38	0.23			None
Typical detection limit at the usual dilution ratio		0.25	0.12	0.04	0.03	0.05	0.002	0.03	0.38	0.12	0.3	0.02	

* These specimens had to be re-used after being used in 25oC test once before.

Analysis was done after diluting the HAN solution with water 1:1, at which point the solutions were still very viscous and aspirated into the AA more slowly than the standards made up in clear water. The standards were made up in 24% HAN solution with the same viscosity to compensate for viscosity effects on sample aspiration flow rate into the AAS. A few post-test samples of off-loaded HAN solutions were analyzed for HAN-assay, but, within the accuracy of the manual titration method, the HAN-content was unchanged from the initial HAN concentration.

3.2.4 Gas Analysis by Gas Chromatography

Analysis of the gas space was performed with a gas chromatograph with a thermoconductivity detector using argon instead of helium as a carrier gas. Two different columns are being used: a 5-ft. X 1/4-in. Porapak-Q column to separate permanent gases and nitrous oxide, and a 6-ft. X 1/4-in. Linde Molecular Sieve 5A column for separation of permanent gases. Table 3.10 is a summary of the gas analysis results obtained. The presence of helium in the post-test gas analyses of the first batch tested at 25°C is an artifact. The ampules had been initially filled with helium, but the helium in the gas space was replaced with argon after 11 days with the intent of replacing all the helium. At that time, the liquid unfortunately was already saturated with helium and the dissolved helium could not be totally removed by simply purging the gas space with argon. The presence of residual helium which had come out of solution did not adversely affect the compatibility results reported here. If the helium in Table 3.10 is ignored, the corrected gas compositions printed in **bold** type in the line below apply instead. The response factor of the GC to helium is higher than that for the other gases when argon is used as the carrier gas. The results were not corrected for the response factor of helium.

Table 3.10: Summary of Gas Analysis

Sample No.	Material Name	Gas Composition, Vol.-% He*	H_2	O_2	N_2	CO_2	N_2O
First Batch at 25 oC							
73A	CRES-301	27.4		16.5	53.9		2.2
				22.7	74.3		3.0
74A	CRES-304	61.9		12.0	26.0		
				31.6	68.4		
134A	Stellite #8 on 17-4PH	54.3		11.3	27.9		6.4
				24.8	61.1		14.1
135A	Stellite #6 on Nicraly on 17-4	55.3		9.7	27.0		7.9
				21.7	60.5		17.7
162A	UCAR LW-15 on 17-4	36.0		10.6	53.4		
				16.6	84.4		
326A	Al-6061	4.7	14.2	0.9	12.1		68.0
Second Batch at 25 oC							
158A	Aeroshell 14			4.1	13.2	75.6	7.1
311A	MG 120 Silver solder			6.1	21.9		72.0
396A	Aeroshell 14			19.5	68.2	12.3	
402A	10W-30 Motor Oil			10.2	32.2	57.6	
412A	SAE 50W Motor Oil			15.5	53.4	31.1	
HB2	HAN\Argon Blank			29.9	70.1		
Ar	Argon Blank			25.2	74.8		
First Batch at 65 oC							
5B	Carbon bearing			2.6	40.7	2.2	54.6
162B	UCAR LW-15 on 17-4			2.0	32.5	2.8	62.7
163B	UCAR LC-1H on 17-4			1.3	39.3	T	59.3
165B	Molydag on 17-4 PH			1.0	41.8	T	57.2
220B	Sermatech GC-WC-111 on 17-4 PH			2.0	35.9	1.1	61.0
266B	Tungsten weld rod			2.4	60.3	T	37.3
310B	Nickel flash on 17-4 PH			1.4	33.6	T	64.9
311B	MG 120 Silver solder			1.3	20.1		78.6
326B	Al-6061		5.1	0.2	31.3		63.3
HB3	HAN\Argon Blank			4.8	76.2		19.0
Ar3	Argon			31.2	68.8		

T = Trace detected

* He dissolved in HAN solution, carried over from previous test method.

Table 3.10 (continued)

Sample No.	Material Name	Gas Composition, Vol.-% H_2	O_2	N_2	CO_2	N_2O
Second Batch at 65 oC						
73B	CRES-301		4.8	72.5		22.7
116B	Graphitar Grade 47		T	73.1		26.9
120B	Tristelle Alloy T5-2		5.3	73.6		21.1
126B	Grease 3451		3.8	69.9		26.3
129B	Victrex 4800G		3.7	66.2		30.1
130B	Victrex Gr. 4101GL20		3.1	58.6		38.3
134B	Stellite #8 on 17-4PH		2.6	51.7		45.7
135B	Stellite #6 on Nicraly on 17-4		1.9	50.4		47.6
145B	Silicon carbide PS-9242		4.0	69.9		26.2
146B	Arlon 1160		0.5	13.3	0.9	85.3
147B	Arlon 1260		2.9	49.9		47.2
156B	Paxon BA 50-100		3.7	68.5		27.7
158B	Aeroshell 17	T		21.9	28.7	49.4
161B	Rulon II		3.7	68.7		27.6
259B	Polyvinylchloride tubing		2.7	61.3	2.3	33.7
335B	Brayco 783E Micronic	T		41.6	4.0	54.4
396B	Aeroshell 14	T		85.7	5.3	9.0
446B	Gladen D20		4.1	73.1		22.8
HB4	HAN\Argon Blank		3.9	72.8		23.3

T = Trace detected

There are several new discoveries in the gas analysis of the gas space above the compatibility test samples: The incompatibility of aluminum alloys with HAN solution resulted in the formation of 5.1 and 14.2% hydrogen. Hydrogen formation had not been previously reported in the literature. However, hydrogen formation would not be surprising since the reaction of HAN solutions with aluminum is similar to reactions of metals with acids. With both aluminum samples tested here, no oxygen was formed by HAN decomposition and whatever little oxygen was found was mostly due to air introduced by the sampling technique.

The other surprise was the high carbon dioxide concentration when testing lubricants with HAN solutions. The highest carbon dioxide concentration, 75.6%, was observed in sample 158A (Aeroshell 14). The second highest carbon dioxide concentration, 57.6%, was found in sample 402A (10W-30 Motor Oil). HAN appears to be a strong oxidizer comparable to concentrated nitric acid and can effectively destroy hydrocarbon bonds in oils and greases. It may be difficult to find a lubricant that is not affected and additional work in this area may be required. Aeroshell 14 was also found to be incompatible based on the rate of gas evolution at either temperature.

All gas samples removed from the test at 338 K (65°C), even the blank control without a material sample in it, had very high nitrous oxide concentrations from HAN decomposition. The highest nitrous oxide concentration, 85.3%, was observed with Arlon 1160. Arlon 1160 was also ruled out for future use because of the high rate of gas evolution at 338 K.

Nitrogen and some oxygen are also formed as decomposition products. In the case of nitrogen and oxygen it is not possible to differentiate between air introduced as an artifact during gas sampling and nitrogen and oxygen formed as the result of HAN decomposition. Isotope labeling would be useful to differentiate the two sources of nitrogen and oxygen.

In the control ampules that were filled with dry argon, there was only a trace of air, but its oxygen to nitrogen ratio had changed somewhat, as if nitrogen had diffused out of the rubber-septum sealed ampules preferentially. Nitrogen has a lower molecular weight than oxygen and would be expected to diffuse faster than oxygen.

3.2.5 Additional Gas Analysis

In the case of two motor oil samples, Valvoline SAE 50W and Kendall 10W-30 tested at 65°C (Sample No. 412B and 402B), it was noted that the mercury on the ampule side of the U-gauge manometer was gradually turning black from a crust of black material forming on the mercury that made it very difficult to read the meniscus. Also, black material adhered to the wall of the tubing. At the completion of the test, a "rotten egg" odor typical for hydrogen sulfide could be noted when removing the septum. When testing the residual gas in the ampule with moist lead acetate paper (a reagent for hydrogen sulfide), it promptly turned black in Sample 412B (Valvoline SAE 50W). The paper in sample 402B did not turn black, but the odor was nevertheless distinct. It appears that some motor oils have sulfur-containing additives (antioxidants) which become reduced by hydroxylamine (hydroxylammonium ion) to hydrogen sulfide.

What makes this observation important is that the same smelly samples also had the lowest rate of gas evolution of all other lubricant samples at 65°C, and no free nitrous oxide could be found with the 25°C tests. However, the 25°C did show formation of carbon dioxide. Some of the oil additives may act as scavengers for ions which otherwise would promote decomposition of HAN solutions.

3.3 KINETIC ANALYSIS OF DECOMPOSITION RATE DATA

The objective of the current study was to determine rates of propellant decomposition and rates of corrosion as a function of temperature and time. The two test temperatures chosen unfortunately were not suitable for an extended kinetic rate analysis of the data. If kinetic rate studies are conducted properly at two temperatures well above the normal storage temperature, far enough apart from each other, it is possible to extrapolate to higher temperatures or longer storage durations using fundamental kinetic rate laws such as the ARRHENIUS relationship for activation energy. In order to be able to extrapolate in an ARRHENIUS plot where the logarithm of the kinetic rate is plotted against the reciprocal absolute temperature, one has to have at least two data points. At the two temperatures chosen for the current contract, insufficient activity was observed at the lower temperature to allow accurate measurement of gas evolution and metals leaching. Those materials that did evolve gas and leached metals at room temperature were those that are obviously incompatible and therefore are of no further interest. It would have been of interest to obtain pairs of gas evolution rate data or metals leaching rate data for materials that are of interest and are considered compatible for all practical purposes.

3.3.1 Gas Evolution Rate Kinetic Analysis

Just to illustrate the principle, although the two examples chosen are not ideally suited because the materials are totally incompatible, the logarithm of the gas evolution rate of samples Al-6061 and Silver Solder MG120 are tabulated in Table 3.11 and plotted in Figure 3.16.

As can be seen from the two lines in the graph, the activation energy of the gas evolving process (i. e. the slope of the straight lines) was very similar. Similar curves should be obtained by testing all compatible materials at two or even three and four different temperatures well above 298 K. Such curves then are useful for prediciting 10-year gas evolution during storage at ambient temperature.

Table 3.11: Kinetic Rate Analysis of Gas Evolution Rates

Sample Designation	Absolute Temperature K	Reciprocal Temperature 1/K	Rate cm3/day	ln Rate
Al-6061	298	0.00336	0.308	-1.1777
Al-6061	338	0.00296	19.80	2.9857
Silver Solder	298	0.00336	0.091	-2.3969
Silver Solder	338	0.00296	7.50	2.0149

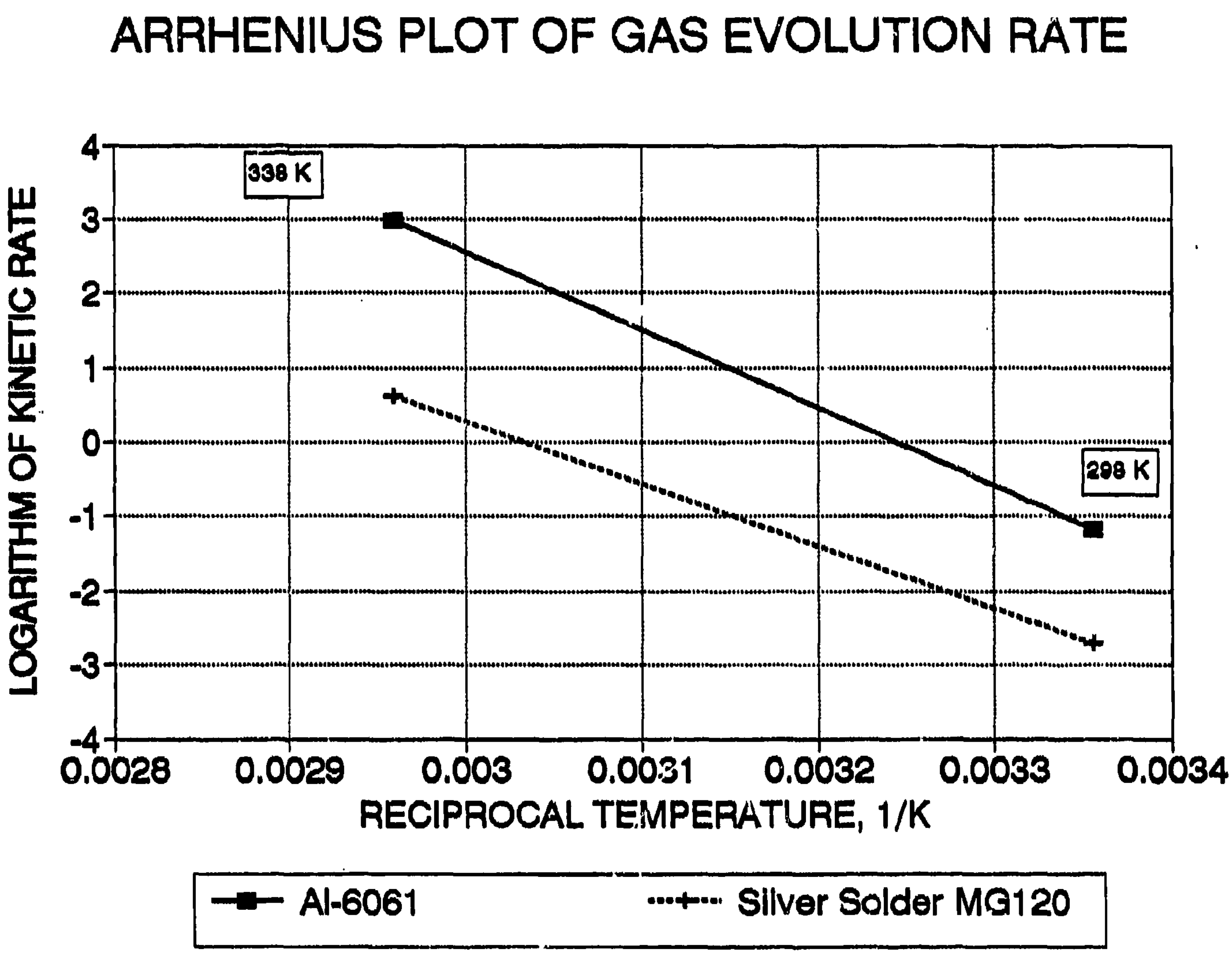


Figure 3.16: ARRHENIUS Plot of Gas Evolution Rates

3.4 SUMMARY AND CONCLUSIONS

The tests described here have shown that some materials are not compatible with 60% HAN solutions and therefore, most likely, also are not suitable for use with LGP-1845 or LGP-1846. It is recommended to place those materials that are shown to be compatible based on the short-term tests described here into a future long-term storage test with continuous measurement of gas evolution and periodical analysis for leached metals. Other samples should be tested in the stressed state. Welded samples and galvanic couples of dissimilar metals need to be tested also.

A test method should be developed that allows the testing of oversize specimens that are too large to fit through the 8-mm neck of the currently used apparatus.

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Appendix A

SAMPLE PRINTOUT FROM HAN COMPATIBILITY DATA BASE

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LIQUID GUN PROPELLANT COMPATIBILITY TEST DATA, UPDATE 25 APRIL 1990, *** FILE LGP-COMP.WK1 ***

Sample No. (GE or other)	Material Name	Generic Name
402	10W-30 MOTOR OIL	OIL/LUBE
127	111 GREASE	
000	13-8 Mo PH	PRECIPITATION HARDENED STEEL
S.C.C.#2	13-8 Mo PH	PRECIPITATION HANDENED STAINLESS
306	15-5 PH	STAINLESS STEEL
306	15-5 PH	STAINLESS STEEL
S.C.C.#1	17-4 PH	PRECIPITATION HARDENED STAINLESS
009	17-4 PH	PRECIPITATION HARDENED STAINLESS
009/S12/S63	17-4 PH	PRECIPITATION HARDENED STAINLESS
000	17-4 PH	STAINLESS STEEL
021	17-4 PH COATED W/EVERLUBE 620C	PRECIPITATION HARDENED STAINLESS
021/S14/S65	17-4 PH COATED W/EVERLUBE 620C	PRECIPITATION HARDENED STAINLESS
026	17-4 PH COATED W/HI-T-LUBE	PRECIPITATION HARDENED STAINLESS
026/S19/S69	17-4 PH COATED W/HI-T-LUBE	PRECIPITATION HARDENED STAINLESS
023	17-4 PH COATED W/METCO 309N5-3	PRECIPITATION HARDENED STAINLESS
023/S16	17-4 PH COATED W/METCO 309N5-3	PRECIPITATION HARDENED STAINLESS
024	17-4 PH COATED W/METCO 505	PRECIPITATION HARDENED STAINLESS
024/S17/S67	17-4 PH COATED W/METCO 505	PRECIPITATION HARDENED STAINLESS
025	17-4 PH COATED W/NEDOX SF-2	PRECIPITATION HARDENED STAINLESS
025/S18/S68	17-4 PH COATED W/NEDOX SF-2	PRECIPITATION HARDENED STAINLESS
022	17-4 PH COATED W/NIBRONZE	PRECIPITATION HARDENED STAINLESS
022/S15/S66	17-4 PH COATED W/NIBRONZE	PRECIPITATION HARDENED STAINLESS
075	17-7 PH	PRECIPITATION HARDENED STAINLESS
075	17-7 PH (MILL ANNNEALED)	STAINLESS STEEL
128	33 GREASE	
126	3451 GREASE	
000	4140 STEEL	
307	4140 STEEL, MODIFIED (TRIAL1)	STEEL
309	4140 STEEL, MODIFIED (TRIAL2)	STEEL
303	4335 STEEL	STEEL
345	4340 STEEL	STEEL
000	4340 STEEL	
218	70/30% Pt-Rh TC ALLOY (-)	THERMOCOUPLE WIRE
217	74/26% W-Re TC ALLOY (-)	THERMOCOUPLE WIRE
215	94/6% Pt-Rh TC ALLOY (+)	THERMOCOUPLE WIRE
216	95/5% W-Re TC ALLOY (+)	THERMOCOUPLE WIRE
LP-35	AERO TEC LABS. ALT-644-30	MISC. ELASTOMER
277	AEROLON 1	
366	AEROQUIP FC 300-12 AQP	
361	AEROQUIP HOSE TEFLON-SS	COMPONENT
360	AEROQUIP #AE246-6 HOSE	
159	AEROSHELL 7 GREASE	GREASE
396	AEROSHELL 14 GREASE	GREASE/LUBE
158	AEROSHELL 17 GREASE	GREASE
158	AEROSHELL 17 GREASE	GREASE/LUBE
157	AEROSHELL 22 GREASE	GREASE
179	Ag PLATE ON 17-4 PH	COATING
017	Al BRONZE COATING ONLY (650TF161)	
016	Al BRONZE COATING (B50TF161) W/UNDERCOAT (B50TF192)	
LP-20	ALCRYN R1101 B70 THP-3	THERMOPLASTIC ELASTOMER
LP-19	ALCRYN R1201 B70A THP-1	THERMOPLASTIC ELASTOMER
365	ALT 644-30 BLADDER MATERIAL	
000	ALUMINUM, SOFT	ALUMINUM
000	ALUMINUM ALLOYS, SOFT	ALUMINUM ALOY

Sample No. (GE or other)	Material Name	Generic Name
369	ALUMINUM Al-356	ALUMINUM ALLOY
326	Al-6061	ALUMINUM ALLOY
326	Al-6061	ALUMINUM
000	Al-7075	ALUMINUM ALLOY
000/S3/S56	Al-7075	METAL
131	AMAX MAGNESIUM	MAGNESIUM
146	ARLON 1160	POLYETHERETHERKETONE
146	ARLON 1160	POLYETHERETHERKETONE
147	ARLON 1260	POLYETHERETHERKETONE
147	ARLON 1260	POLYETHERETHERKETONE
071	BALSTON FILTER #050-05-BX	
069	BALSTON FILTER #050-05-BH	
070	BALSTON FILTER #050-05-BQ	
039	BALSTON FILTER #050-05-CH	
038	BALSTON FILTER #050-05-CQ	
149	BEACON 325 GREASE	
370	BERYLLIUM BRONZE SILVER PLATED VALVE	SILVER PLATING
304	BLUE RECORDING INK	
352	BRASS (PROJECTILE)	BRASS
335	BRAYCO 783E MICRONIC	OIL/LUBE
330	BRAYCO 726	
329	BRAYCO 726	
340	BRAYCO 756	
339	BRAYCO 756	
336	BRAYCO 783E	
335	BRAYCO 783E	
327	BRAYCO 864	
328	BRAYCO 864	
252	BRAYCO MICRONIC 762 FLUID	
253	BRAYCO MICRONIC 762 FLUID	
254	BRAYCO MICRONIC 882 FLUID	
255	BRAYCO MICRONIC 882 FLUID	
358	BREAK-FREE	
357	BREAK-FREE	
271	BUNA-N CODE P	RUBBER
270	BUTYL 3Q86 CODE C	RUBBER
123	C100 GREASE	GREASE
005	CARBON BEARING	GRAPHITE
265	CERAMIC MAGNET (TEMPSONICS)	
286	CERAMIC MAGNET - CC12 (ORANGE RES.)	
006	CERAMIC THRUST WASHER	CERAMIC
000/S5/S58	CHROMIUM	METAL
106	CONFORMA CLAD WC 300 COATING	
000/S6	COPPER	METAL
000	COPPER ALLOYS	COPPER ALLOY
000	COPPER ALLOYS	COPPER
313	COPPER SHAVINGS	COPPER
083	CrB2 COATING ON 17-4 PH	CHROMIUM BORIDE
083/S43/S93	CrB2 COATING ON 17-4 PH	CHROMIUM BORIDE
073	CRES-301	STAINLESS STEEL
073	CRES-301	STAINLESS STEEL
268	CRES-302	STAINLESS STEEL
268	CRES-302	STAINLESS STEEL
055	CRES-303	STAINLESS STEEL
055/S38/S88	CRES-303	STAINLESS STEEL

Sample No. (GE or other)	Material Name	Generic Name
000	CRES-304	AUSTENITIC STAINLESS STEEL
074	CRES-304	STAINLESS STEEL
074	CRES-304	AUSTENITIC STAINLESS STEEL
269	CRES-308	STAINLESS STEEL
269	CRES-308	STAINLESS STEEL
S.C.C.#5	CRES-316	STAINLESS STEEL
263	CRES-316	STAINLESS STEEL
000	CRES-316	STAINLESS STEEL
263	CRES-316	STAINLESS STEEL
000/S4/S57	CRES-316	STAINLESS STEEL
000	CRES-416	STAINLESS STEEL
000	CRES-416	STAINLESS STEEL
000	CRES-440C	STAINLESS STEEL
000	CRES-44C	STAINLESS STEEL
014	CRES-454 CUSTOM	STAINLESS STEEL
104	DELRIN 100ST	ACETAL RESIN
119	DELRIN 500	ACETAL RESIN
103	DELRIN 500T	ACETAL RESIN
096	DELRIN ACETAL	ACETAL RESIN
027	DELRIN (ACETAL BASE)	ACETAL RESIN
LP-28	DISOGRIN CD-9250	THERMOPLASTIC ELASTOMER
168	DISOGRIN COMPOUND 6865-RING	POLYURETHANE
160	DISOGRIN COMPOUND 9250	POLYURETHANE
169	DISOGRIN COMPOUND 9250-RING	POLYURETHANE
188	DOW CORNING 200 FLUID, 10.0 CS	SILICONE OIL
189	DOW CORNING 200 FLUID, 10.0 CS	SILICONE OIL
190	DOW CORNING 200 FLUID, 1.0 CS	SILICONE OIL
191	DOW CORNING 200 FLUID, 1.0 CS	SILICONE OIL
184	DOW CORNING 200 FLUID, 2.0 CS	SILICONE OIL
185	DOW CORNING 200 FLUID, 2.0 CS	SILICONE OIL
187	DOW CORNING 200 FLUID, 5.0 CS	SILICONE OIL
183	DOW CORNING 200 FLUID, 5.0 CS	SILICONE OIL
356	DOW CORNING SILICONE SEALANT	SILICONE RUBBER
000	DOW CORNING #33 GREASE	
062	DO-ALL BLUE "STEEL INK" LAYOUT DYE	INK
273	EDPM, CODE H	
195	EMERY 2943-D FRIGID-GO HYDR. FLUID	
194	EMERY 2943-D FRIGID-GO HYDR. FLUID	
197	EMERY 2946-A SYNTHETIC HYD. FLUID	
196	EMERY 2946-A SYNTHETIC HYD. FLUID	
099	ENERPAC HYDRAULIC OIL	
097	ENERPAC HYDRAULIC OIL	
098	ENERPAC HYDRAULIC OIL	
316	EOPZY PRIMER (ZINC CHROMATE), PC	
314	EPOXY ENAMEL PAINT, PC-BRAND-PEN-RUST	
315	EPOXY ENAMEL PAINT, PC-BRAND-PEP-1	
LP-18	EPR REEVES 4594 (GUM)	ETHYLENE-PROPYLENE-POLYMER
LP-17	EPR REEVES 4601 (GUM)	ETHYLENE-PROPYLENE-POLYMER
248	ERIFON 818 FLUID	
249	ERIFON 818 FLUID	
262	ETHYLENE PROPYLENE (1ST SOURCE)	SYNTHETIC RUBBER EPR
264	ETHYLENE PROPYLENE (2ND SOURCE)	POLYETHYLENE POLYPROPYLENE
32[illegible]	ETHYLENE PROPYLENE - EPDM #9214-801	SYNTHETIC RUBBER
325	ETHYLENE PROPYLENE - EPR #9214-952	(SYNTHETIC RUBBER

Sample No. (GE or other)	Material Name	Generic Name
032	FERRALIUM ALLOY 255	
113	FERRALIUM ALLOY 255	"SUPER" ALLOY
113	FERRALIUM ALLOY 255 (RETEST)	STAINLESS STEEL
346	FLOOR 1	
347	FLOOR 2	
239	FLUORINERT FC-40	
240	FLUORINERT FC-40	
221	FLUORINERT FC-75	
222	FLUORINERT FC-75	
237	FLUORINERT FC-84	
238	FLUORINERT FC-84	
171	FLUORINERT ELECTRONIC LIQUID FC-77	
172	FLUORINERT ELECTRONIC LIQUID FC-77	
078	FLUOROCARBON PEEK	POLYETHERETHERKETONE
078/S41/S91	FLUOROCARBON PEEK	POLYETHERETHERKETONE
323	FLUOROCARBON RUBBER - VITON #9214-77	SYNTHETIC RUBBER
321	FLUOROCARBON RUBBER-VITON #9214-731	SYNTHETIC RUBBER
077	FLUOROCARBON - 33	
077/S40/S90	FLUOROCARBON - 33	
LP-16	FLURAN F-5500-1 NORTON IND.	FLUOROELASTOMER
107	FOAM MAT'L FROM ENVIRON CHAMBER	PLASTIC FOAM
176	FREON MF	
175	FREON MF	
178	FREON TF	CHLOROFLUOROCARBON
177	FREON TF	CHLOROFLUOROCARBON
192	FRIGID-GO SYNTHETIC OIL SAE OW-20	
193	FRIGID-GO SYNTHETIC OIL SAE OW-20	
125	G321 GREASE	
LP-24	GAFLEX	THERMOPLASTIC ELASTOMER
446	GALDEN D20	UNKNOWN
289	GOLD PLATED BERYLLIUM BRONZE	
LP-36	GOODYEAR COLLAPSIBLE TANK	NITRILE/PVC BLEND
116	GRAPHITAR GRADE 47	GRAPHITE
011	GRAPHITAR GRADE 47	GRAPHITE
126	GREASE 3451	GREASE/LUBE
109	GREEN/WHITE PAINTED MAT'L FROM CHAMB	COATING
052	GRILON #BT-40	NYLON-6
000	GROUP II METALS (Zn, Cd, Pb, Sn)	
000	GROUP II METALS (Zn,Cd,Pb,Sn, etc.)	
200	G-354 GREASE	
224	HALOCARBON .8 OIL	
223	HALOCARBON .8 OIL	
230	HALOCARBON 1.8 OIL	
229	HALOCARBON 1.8 OIL	
226	HALOCARBON 6.3 OIL	
225	HALOCARBON 6.3 OIL	
084	HARD CHROME COATING ON 17-4 PH	CHROMIUM COATING
084/S44/S94	HARD CHROME COATING ON 17-4 PH	CHROMIUM COATING
000	HASTELLOYS	NICKEL ALLOY
112	HAYNES ALLOY 25	COBALT ALLOY
112	HAYNES ALLOY 255	"SUPER" ALLOY
111	HAYNES ALLOY 718	NICKEL ALLOY
111/S102	HAYNES ALLOY 718	NICKEL ALLOY
007	HIGH STRENGTH POLYAMIDE #05-036	POLYAMIDE
008	HIGH STRENGTH POLYAMIDE #05-059	POLYAMIDE

Sample No. (GE or other)	Material Name	Generic Name
274	HIMOD 550	
275	HIMOD 551	
276	HIMOD 552	
026	HI-T-LUBE COATING ON 17-4 PH	
150	HI-T-LUBE ON 17-4	
102	HOSTALEN UHMW POLYMER	
102/S49/S99	HOSTALEN UHMW POLYMER	
246	HYDRAULIC 2105	
247	HYDRAULIC 2105	
290	HYPODERMIC NEEDLE	
050	HYTREL #7246	POLYESTER ELASTOMER
050/S34/S84	HYTREL #7246	POLYESTER ELASTOMER
S.C.C.#4	INCO 718	NICKEL ALLOY
199	ION-NITRIDED 17-4 PH	
000/S2	IRON	METAL
053	JESSOP JS ALLOY 20 (UNS NO8020)	STAINLESS STEEL 20Cb3
053/S36/S86	JESSOP JS ALLOY 20 (UNS NO8020)	STAINLESS STEEL 20Cb3
054	JESSOP JS ALLOY 276 (UNS 10276)	STAINLESS STEEL 20Cb3
054/S37/S87	JESSOP JS ALLOY 276 (UNS 10276)	STAINLESS STEEL 20Cb3
S.C.C.#7	JESSOP STEEL 20	
S.C.C.#6	JESSOP STEEL 276	
080	JESSOP STEEL 276	
205	KENDALL DEXRON II FLUID	
206	KENDALL DEXRON II FLUID	
204	KENDEX 8895 FLUID	
203	KENDEX 8895 FLUID	
086	KENNAMETAL K602	
086/S45/S95	KENNAMETAL K602	
087	KENNAMETAL K701	TUNGSTEN ALLOY
089	KENNAMETAL K801	
089	KENNAMETAL K801	TUNGSTEN ALLOY
089/S46/S96	KENNAMETAL K801	
088	KENNAMETAL SPZ 313	TUNGSTEN ALLOY
332	KENSOL 48T	
331	KENSOL 48T	
202	KENSOL 48T FLUID	
201	KENSOL 48T FLUID	
LP-34	KRATON-1650, ILC DOVER	THERMOPLASTIC ELASTOMER
003	KYNAR LINING	PVDF
105	K-KARB	
105/S100	K-KARB	
028	K-RAMIC #SCA-1002 COATING	
028/S20/S70	K-RAMIC #SCA-1002 COATING	
164	LCO-17 COATING ON 17-4	
163	LC-1H COATING ON 17-4	
000	LEXAN	POLYCARBONATE
368	LOCTITE 609	
061	LOCTITE PRIMER N	PAINT
059	LOCTITE #220	
060	LOCTITE #609	
000	LUCITE	POLYMETHYLMETHACRYLATE
162	LW-15 COATING ON 17-4	
257	M2 TOOL STEEL (FULL SULFURIZED)	STEEL
256	M2 TOOL STEEL (PART SULFURIZED)	STEEL

Sample No. (GE or other)	Material Name	Generic Name
334	MACHINIST'S LUBRICANT - PITTSFIELD	
333	MACHINIST'S LUBRICANT - PITTSFIELD	
151	MAGNAGOLD	
151	MAGNAGOLD ON 17-4	
245	MAGNALUBE G - GREASE	
068	MATERIAL FROM FUME HOOD INTERIOR	
023	METCO #309NS-3 COATING ON 17-4 PH	
034	METCO #350 ON 17-4 PH	
024	METCO #505 ON 17-4 PH	
020	METCO #605 NS W/UNDERCOAT (B50TF192)	
018	METCO #605NS	
036	METCO #74SF ON 17-4 PH	
354	METHYLENE BLUE	
311	MG 120 SILVER SOLDER	SOLDER
311	MG 120 SILVER SOLDER 96/4% Sn-Ag	SILVER SOLDER
244	MIL H 83282 B HYD. FLUID	
243	MIL H 83282 B HYD. FLUID	
LP-32	MILLATHANE E34, TSE-E-34-94,TSE IND.	POLYURETHANE
LP-22	MOBAY TEXIN 355DR	THERMOPLASTIC ELASTOMER
LP-23	MOBAY TEXIN 480 AR	THERMOPLASTIC ELASTOMER
298	MOBIL 1 5W-30	SILICONE OIL
297	MOBIL 1 5W-30	SILICONE OIL
342	MOBIL HFA	
341	MOBIL HFA	
296	MOBIL SHC 524	
295	MOBIL SHC 524	
299	MOBIL SHC 525	
300	MOBIL SHC 525	
302	MOBIL SHC 526	
301	MOBIL SHC 526	
165	MOLYDAG COATING ON 17-4	
165	MOLYDAG ON 17-4 PH	LUBE/DRY
LP-21	MONSANTO GEOLAST 701-80	THERMOPLASTIC ELASTOMER
082	MoS2 COATING - EVERLUBE ON 17-4	MOLYBDENUM DISULFIDE
351	MP35N STEEL	
S.C.C.#3	MP-355	STAINLESS STEEL
012	MYKROY/MYCALEX 555/751	GLASS BONDED MICA
025	NEDOX SF-2 COATING ON 17-4 PH	
355	NEODYNIUM-MAGNET	
272	NEOPRENE, CODE J	
022	NIBRON COATING ON 17-4 PH	
000/S55	NICKEL	METAL
310	NICKEL FLASH ON 17-4 PH	ELECTROPLATING
310	NICKEL FLASHED COATING ON 17-4PH	NICKEL
261	NITINOL WIRE	
166	NITRIDED TRIBOCOR 532N	
166	NITRIDED TRIBOCOR 532N	COATING
LP-01	NITRILE ELASTOMER NBR-2	NITRILE RUBBER
LP-02	NITRILE ELASTOMER NBR-8	NITRILE RUBBER
LP-03	NITRILE ELASTOMER NBR-9	NITRILE RUBBER
320	NITRILE OR BUNA-N #9214-700 (GREENE	SYNTHETIC RUBBER
110	NITRONIC 50	STAINLESS STEEL
110/S101	NITRONIC 50	STAINLESS STEEL
000	NITRONIC 60 (CRE)	STAINLESS STEEL
003	Ni-RESIST GRADE C	

Sample No. (GE or other)	Material Name	Generic Name
LP-29	NORPRENE, NORTON IND.	THERMOPLASTIC ELASTOMER
046	NYLASINT #M4	
046/S30/S80	NYLASINT #M4	
260	NYLATRON GS - POPPET	
006/S10/S61	NYLON 05-037	POLYAMIDE
006	NYLON #05-037	POLYAMIDE
251	OCEANIC HW 560	
250	OCEANIC HW 560	
115	O-RING ROD SEAL SHEFFER ACTUATOR	
198	PACKED BORIDED 17-4 PH	BORIDE COATING
319	PAINT, TEMP. (1500 DEG. F) SENSING	
318	PAINT, TEMP. (2500 DEG. F) SENSING	
156	PAXON BA 50-100	
156	PAXON BA 50-100	POLYETHYLENE
063	PEBAX #2533 SN00	POLYETHERBLOCKAMIDE
064	PEBAX #3533 SN00	POLYETHERBLOCKAMIDE
065	PEBAX #4033 SN00	POLYETHERBLOCKAMIDE
066	PEBAX #5533 SN00	POLYETHERBLOCKAMIDE
067	PEBAX #6333 SN00	POLYETHERBLOCKAMIDE
232	PENWALT KSL-213	
231	PENWALT KSL-213	
233	PENWALT KSL-550	
234	PENWALT KSL-550	
235	PENWALT SPINDLE OIL 4	
236	PENWALT SPINDLE OIL 4	
353	PERMALON-M LUBRICANT	
173	PEURECO-DRAKEOL 10B LT MIN OIL NF	
174	PEURECO-DRAKEOL 10B LT MIN OIL NF	
322	PHOSPHONITRILIC FLUOROELASTOMER #921	SYNTHETIC RUBBER
065	PISTON FROM FS-925 FLOW SWITCH	
013	POCO GRAPHITE #ACF-10QE2	GRAPHITE
013/S13/S64	POCO GRAPHITE #ACF-10QE2	GRAPHITE
007/S11/S62	POLYAMIDE 05-036	POLYAMIDE
LP-30	POLYESTER URETHANE PU-1	POLYURETHANE
LP-31	POLYESTER URETHANE PU-2	POLYURETHANE
287	POLYETHER URETHANE	POLYETHER URETHANE
000	POLYETHYLENE	POLYETHYLENE
LP-37	POLYMER PE-100-A-027 ILC DOVER	MISC. ELASTOMER
000	POLYPROPYLENE	POLYPROPYLENE
259	POLYVINYL CHLORIDE TUBING	POLYVINYLCHLORIDE
259	POLYVINYLCHLORIDE TUBING	PVC
219	PRESSURE TRANSDUCER	
145	PS-9242 SILICON CARBIDE	SILICON CARBIDE
132	PURE PETROLEUM BASE OIL-30 WEIGHT-ALVANIA 2 -SHELL	
LP-04	RADIAN 1203-F60-R2	NITRILE/PVC BLEND
LP-05	RADIAN VT-380	NITRILE/PVC BLEND
LP-15	REEVES S/4616 (GUM)	FLUOROELASTOMER
308	REFLECTIVE TAPE FOR OPTRON	
076	REXNORD DURALON BEARING MAT'L	
LP-11	RUBBER CR-1	POLYCHLOROPRENE
LP-12	RUBBER CR-2	POLYCHLOROPRENE
161	RULON II	POLYMER
161	RULON II	POLYMER
100	RYNITE SST-35	THERMOPLASTIC POLYESTER RESIN

Sample No. (GE or other)	Material Name	Generic Name
049	RYNITE #530	THERMOPLASTIC POLYESTER RESIN
049/S33/S83	RYNITE #530	THERMOPLASTIC POLYESTER RESIN
412	SAE 50W MOTOR OIL	OIL/LUBE
LP-26	SANTOPRENE 101-64	THERMOPLASTIC ELASTOMER
LP-27	SANTOPRENE 101-73	THERMOPLASTIC ELASTOMER
LP-25	SANTOPRENE 201-55	THERMOPLASTIC ELASTOMER
148	SEAL FOR 6 IN. BORE CYLINDER	
220	SERMATECH GC-WC-111 ON 17-4 PH	COATING
220	SERMATECH GG-wc-111 ON 17-4	
214	SHELL 35 BASE OIL	
213	SHELL 35 BASE OIL	
212	SHELL 45 BASE OIL	
211	SHELL 45 BASE OIL	
210	SHELL 60 SPRAY BASE 69013	
209	SHELL 60 SPRAY BASE 69013	
019	SILICON CARBIDE	SILICON CARBIDE
145	SILICON CARBIDE PS-9242	CARBIDE
278	SILICONE, CODE L	SILICONE RUBBER
305	SILICONE RTV SEALANT	SILICONE RUBBER
317	SILVER GOOP - NON SEIZING COMPOUND	
179	SILVER PLATING ON 17-4	SILVER
114	SLIP RING FROM SHEFFER ACTUATOR	
000	STEEL 4140	STEEL
000	STEEL 4340	STEEL
351	STEEL MP35N	STEEL
000	STELLITE	SUPERALLOY
081	STELLITE #1016 WELD ROD	COBALT ALLOY
079	STELLITE #21 WELD ROD	COBALT ALLOY
079/S42/S92	STELLITE #21 WELD ROD	COBALT ALLOY
134	STELLITE #6 COATING ON 17-4PH	COBALT HARDFACE ALLOY
135	STELLITE #6 ON NICRALY ON 17-4	COATING
035	STELLITE #6 PLASMA SPRAYED (TTL)	COBALT ALLOY
138	STELLITE #6 PLASMA TRANSFER ARC	COBALT ALLOY
134	STELLITE #8 ON 17-4PH	COATING
169	STRATOFLEX 124-8 TEFLON HOSE	
170	STRATOFLEX 124-8 TEFLON HOSE W/ CARBON BLACK	
208	SUNISCO 3GS FLUID	
207	SUNISCO 3GS FLUID	
007	SUPERPROLINE	PVDF
359	SYNFLEX HOSE #3130-06	
180	SYNTHETIC OIL 168 (NYE) 1:2	
181	SYNTHETIC OIL 168 (NYE) 2:1	
183	SYNTHETIC OIL 237A LOT U260 (NYE)	
182	SYNTHETIC OIL 237A LOT U260 (NYE)	
294	SYNTHETIC TORQUE OIL	
293	SYNTHETIC TORQUE OIL	
362	TANTALUM	TANTALUM
000/S1/S54	TANTALUM	METAL
258	TANTALUM COATING	TANTALUM
258	TANTALUM COATING	COATING
005/S9/S60	TEFLON 05-002	FLUOROCARBON POLYMER
004/S8/S59	TEFLON 05-026	FLUOROCARBON POLYMER
005	TEFLON 05-002	POLYTETRAFLUOROETHYLENE
004	TEFLON 05-026	POLYTETRAFLUOROETHYLENE
072	TEFLON 55450-3 (VIRGIN)	POLYTETRAFLUOROETHYLENE

Sample No. (GE or other)	Material Name	Generic Name
072/S39/S89	TEFLON 55450-3 (VIRGIN)	POLYTETRAFLUOROETHYLENE
002	TEFZEL LINING	ETFE
338	TEXACO AIRCRAFT OIL 15	
337	TEXACO AIRCRAFT OIL 15	
091	TIODIZE TIOLUBE 1175	HIGH PRESSURE DRY FILM LUBRICANT
091/S47/S97	TIODIZE TIOLUBE 1175	HIGH PRESSURE DRY FILM LUBRICANT
101	TIODIZE TRIBO/COMP TDF	
090	TIOLUBE 660	
363	TITANIUM IMPLANTED WITH NITROGEN	TITANIUM NITRIDE
364	TITANIUM NITRIDE COATING	TITANIUM NITRIDE
137	TORLON 7130 - RETEST	POLYAMIDE-IMIDE
051	TORLON 4275	POLYAMIDE-IMIDE
051/S35/S85	TORLON 4275	POLYAMIDE-IMIDE
031	TORLON 7130	POLYAMIDE-IMIDE
031/S23/S73	TORLON 7130	POLYAMIDE-IMIDE
LP-33	TREAD 3130	MISC. ELASTOMER
015	TRIBALOY T-400 (BSOTF155) W/UNDERCOAT (BSOTF192)	
118	TRIBALOY T-700	
037	TRIBALOY T-800 ON 17-4 PH	
120	TRISTELLE ALLOY T5-2	METAL
120	TRISTELLE ALLOY TS-2	METAL
117	TUF-LOC PT-707 BEARING	
019	TUNGSTEN CARBIDE (B50TF27) W/UNDERCOAT (B50TF192)	
266	TUNGSTEN WELD ROD	
266	TUNGSTEN WELD ROD	TUNGSTEN
282	TURCON 14	
283	TURCON 19	
280	TURCON 5	
281	TURCON 7	
279	TURCON 99	
163	UCAR LC-1H ON 17-4	COATING
162	UCAR LW-15 ON 17-4	COATING
044	UDEL P-1700	POLYSULFONE
044/S29/S79	UDEL P-1700	POLYSULFONE
045	ULTEM 4001	POLYETHERIMIDE RESIN
LP-06	UNIROYAL BJLT M-40	NITRILE RUBBER
LP-07	UNIROYAL OZO-HA-0221	NITRILE/PVC BLEND
242	UNISAFE 40	
241	UNISAFE 40	
344	UNIVIS J13	
343	UNIVIS J13	
136	U/C NICRALY & TOPCOAT CHROME CARBIDE/NICHROME	
135	U/C NICRALY & TOPCOAT STELLITE #6	
094	VASCO MATRIX I	
095	VASCO MATRIX II	
092	VASCOMAX C-250	STEEL
349	VASCOMAX C-300	MARAGING STEEL
350	VASCOMAX C-350	MARAGING STEEL
093	VASCOMAX T-250	STEEL
348	VASCOMAX T-300	MARAGING STEEL
043	VESPEL #SP-1	
043/S28/S77	VESPEL #SP-1	
040	VESPEL #SP-21	
033	VESPEL #SP-21	
033/S24/S74	VESPEL #SP-21	

Sample No. (GE or other)	Material Name	Generic Name
029	VESPEL #SP-210 15% GRAPHITE	GRAPHITE
029/S21/S71	VESPEL #SP-210 15% GRAPHITE	GRAPHITE
041	VESPEL #SP-211	
041/S26/S75	VESPEL #SP-211	
030	VESPEL #SP-211D156968	
030/S22/S72	VESPEL #SP-211D156968	
042	VESPEL #SP-22	
042/S27/S76	VESPEL #SP-22	
129	VICTREX 4800G	POLYMER
129	VICTREX 4800G	POLYMER
130	VICTREX GRADE 4101GL20	POLYETHERETHERKETONE, 20% GLASS
130	VICTREX GR. 4101GL20	POLYMER
292	VIPLEX L-60	LIQUID PLASTICIZER IN VINYL
291	VIPLEX L-60	LIQUID PLASTICIZER IN VINYL
000	VITON	FLUOROELASTOMER
284	VITON, CODE T	FLUOROELASTOMER
LP-13	VITON-1	FLUOROELASTOMER
LP-14	VITON-2	FLUOROELASTOMER
154	WHITE BLADDER MAT'L	
LP-08	XNBR-2	CARBOXYLATED NITRILE RUBBER
LP-09	XNBR-3	CARBOXYLATED NITRILE RUBBER
LP-10	XNBR-6	CARBOXYLATED NITRILE RUBBER
153	YELLOW BLADDER MAT'L THICK	
155	YELLOW BLADDER MAT'L THIN	
017	ZIRCONIUM ZR-702	ZIRCONIUM
018	ZIRCONIUM ZR-705	ZIRCONIUM
285	ZURCON 449	
047	ZYTEL #101L	NYLON RESIN
047/S31/S81	ZYTEL #101L	NYLON RESIN
048	ZYTEL #70643L	NYLON RESIN
048/S32/S82	ZYTEL #70643L	NYLON RESIN

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
10W-30 MOTOR OIL	LUBRICANT	ROCKET RESEARCH	60.8% HAN	1:20	25 AND 65 oC
111 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
13-8 Mo PH	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
13-8 Mo PH	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
15-5 PH	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
15-5 PH	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
17-4 PH	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
17-4 PH	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH COATED W/EVERLUBE 620C	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH COATED W/EVERLUBE 620C	COATING	SUNDSTRAND	60% HAN		25 and 65 oC
17-4 PH COATED W/HI-T-LUBE	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH COATED W/HI-T-LUBE	COATING	SUNDSTRAND	60% HAN		25 and 65 oC
17-4 PH COATED W/METCO 309N5-3	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH COATED W/METCO 309N5-3	COATING	SUNDSTRAND	60% HAN		25 oC
17-4 PH COATED W/METCO 505	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH COATED W/METCO 505	COATING	SUNDSTRAND	60% HAN		25 and 65 oC
17-4 PH COATED W/NEDOX SF-2	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH COATED W/NEDOX SF-2	COATING	SUNDSTRAND	60% HAN		25 and 65 oC
17-4 PH COATED W/NIBRONZE	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-4 PH COATED W/NIBRONZE	COATING	SUNDSTRAND	60% HAN		25 and 65 oC
17-7 PH	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
17-7 PH (MILL ANNNEALED)	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
33 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
3451 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
4140 STEEL	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
4140 STEEL, MODIFIED (TRIAL1)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
4140 STEEL, MODIFIED (TRIAL2)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
4335 STEEL	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
4340 STEEL	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
4340 STEEL	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
70/30% Pt-Rh TC ALLOY (-)	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
74/26% W-Re TC ALLOY (-)	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
94/6% Pt-Rh TC ALLOY (+)	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
95/5% W-Re TC ALLOY (+)	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
AERO TEC LABS. ALT-644-30	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
AEROLON 1		GENERAL ELECTRIC	LGP-1846		AMBIENT
AEROQUIP FC 300-12 AQP		GENERAL ELECTRIC	LGP-1846		AMBIENT
AEROQUIP HOSE TEFLON-SS	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
AEROQUIP #AE246-6 HOSE	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
AEROSHELL 7 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
AEROSHELL 14 GREASE	LUBRICANT	ROCKET RESEARCH	60.8% HAN	1:27	25 AND 65 oC
AEROSHELL 17 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
AEROSHELL 17 GREASE	LUBRICANT	ROCKET RESEARCH	60.8% HAN	1:27	25 AND 65 oC
AEROSHELL 22 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
Ag PLATE ON 17-4 PH	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
Al BRONZE COATING ONLY (650TF161)		GENERAL ELECTRIC	LGP-1846		AMBIENT
Al BRONZE COATING (B50TF161) W/UNDE	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
ALCRYN R1101 B70 THP-3	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
ALCRYN R1201 B70A THP-1	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
ALT 644-30 BLADDER MATERIAL	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
ALUMINUM, SOFT	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
ALUMINUM ALLOYS, SOFT	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
ALUMINUM Al-356	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
Al-6061	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
Al-6061	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
Al-7075	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
Al-7075	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
AMAX MAGNESIUM	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
ARLON 1160	POLYMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
ARLON 1160	POLYMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
ARLON 1260	POLYMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
ARLON 1260	POLYMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
BALSTON FILTER #050-05-BX	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
BALSTON FILTER #050-05-BH	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
BALSTON FILTER #050-05-BQ	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
BALSTON FILTER #050-05-CH	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
BALSTON FILTER #050-05-CQ	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
BEACON 325 GREASE	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
BERYLLIUM BRONZE SILVER PLATED VALV	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
BLUE RECORDING INK	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
BRASS (PROJECTILE)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
BRAYCO 783E MICRONIC	LUBRICANT	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
BRAYCO 726		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
BRAYCC 726		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
BRAYCO 756		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
BRAYCO 756		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
BRAYCO 783E		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
BRAYCO 783E		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
BRAYCO 864		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
BRAYCO 864		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
BRAYCO MICRONIC 762 FLUID		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
BRAYCO MICRONIC 762 FLUID		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
BRAYCO MICRONIC 882 FLUID		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
BRAYCO MICRONIC 882 FLUID		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
BREAK-FREE	DETERGENT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
BREAK-FREE	DETERGENT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
BUNA-N CODE P	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
BUTYL 3Q86 CODE C	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
C100 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
CARBON BEARING	CERAMIC	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
CERAMIC MAGNET (TEMPSONICS)	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
CERAMIC MAGNET - CC12 (ORANGE RES.)		GENERAL ELECTRIC	LGP-1846		AMBIENT
CERAMIC THRUST WASHER	COMPONENT	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
CHROMIUM	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
CONFORMA CLAD WC 300 COATING	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
COPPER	METAL	SUNDSTRAND	60% HAN		25 oC
COPPER ALLOYS		GENERAL ELECTRIC	LGP-1846		AMBIENT
COPPER ALLOYS	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
COPPER SHAVINGS	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CrB2 COATING ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
CrB2 COATING ON 17-4 PH	COATING	SUNDSTRAND	60% HAN		25 and 65 oC
CRES-301	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
CRES-301	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-302	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-302	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
CRES-303	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-303	METAL	SUNDSTRAND	60% HAN		25 and 65 oC

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
CRES-304	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-304	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
CRES-304	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-308	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-308	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
CRES-316	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-316	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-316	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-316	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
CRES-316	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
CRES-416	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-416	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-440C	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-44C	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
CRES-454 CUSTOM	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
DELRIN 100ST	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
DELRIN 500	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
DELRIN 500T	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
DELRIN ACETAL	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
DELRIN (ACETAL BASE)		GENERAL ELECTRIC	LGP-1846		AMBIENT
DISOGRIN CD-9250	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
DISOGRIN COMPOUND 6865-RING	ELASTOMER (THERMOPLAS	GENERAL ELECTRIC	LGP-1846		AMBIENT
DISOGRIN COMPOUND 9250	ELASTOMER (THERMOPLAS	GENERAL ELECTRIC	LGP-1846		AMBIENT
DISOGRIN COMPOUND 9250-RING	ELASTOMER (THERMOPLAS	GENERAL ELECTRIC	LGP-1846		AMBIENT
DOW CORNING 200 FLUID, 10.0 CS	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
DOW CORNING 200 FLUID, 10.0 CS	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
DOW CORNING 200 FLUID, 1.0 CS	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
DOW CORNING 200 FLUID, 1.0 CS	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
DOW CORNING 200 FLUID, 2.0 CS	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
DOW CORNING 200 FLUID, 2.0 CS	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
DOW CORNING 200 FLUID, 5.0 CS	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
DOW CORNING 200 FLUID, 5.0 CS	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
DOW CORNING SILICONE SEALANT	SEALANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
DOW CORNING #33 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
DO-ALL BLUE "STEEL INK" LAYOUT DYE	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
EDPM, CODE H	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
EMERY 2943-D FRIGID-GO HYDR. FLUID	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
EMERY 2943-D FRIGID-GO HYDR. FLUID	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
EMERY 2946-A SYNTHETIC HYD. FLUID	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
EMERY 2946-A SYNTHETIC HYD. FLUID	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
ENERPAC HYDRAULIC OIL	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
ENERPAC HYDRAULIC OIL	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	1:1	AMBIENT
ENERPAC HYDRAULIC OIL	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
EOPZY PRIMER (ZINC CHROMATE), PC	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
EPOXY ENAMEL PAINT, PC-BRAND-PEN-RU	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
EPOXY ENAMEL PAINT, PC-BRAND-PEP-1	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
EPR REEVES 4594 (GUM)	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
EPR REEVES 4601 (GUM)	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1346		23 oC
ERIFON 818 FLUID		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
ERIFON 818 FLUID		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
ETHYLENE PROPYLENE (1ST SOURCE)	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
ETHYLENE PROPYLENE (2ND SOURCE)	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
ETHYLENE PROPYLENE - EPDM #9214-801	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
ETHYLENE PROPYLENE - EPR #9214-952	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
[illegible]		GENERAL ELECTRIC	LGP-1846		AMBIENT

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
FERRALIUM ALLOY 255	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
FERRALIUM ALLOY 255	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
FERRALIUM ALLOY 255 (RETEST)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
FLOOR 1	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
FLOOR 2	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
FLUORINERT FC-40	ELECTRONIC FLUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
FLUORINERT FC-40	ELECTRONIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
FLUORINERT FC-75	ELECTRONIC FLUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
FLUORINERT FC-75	ELECTRONIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
FLUORINERT FC-84	ELECTRONIC FLUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
FLUORINERT FC-84	ELECTRONIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
FLUORINERT ELECTRONIC LIQUID FC-77	ELECTRONIC LIQUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
FLUORINERT ELECTRONIC LIQUID FC-77	ELECTRONIC LIQUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
FLUOROCARBON PEEK	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
FLUOROCARBON PEEK	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
FLUOROCARBON RUBBER - VITON #9214-7	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
FLUOROCARBON RUBBER-VITON #9214-731	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
FLUOROCARBON - 33		GENERAL ELECTRIC	LGP-1846		AMBIENT
FLUOROCARBON - 33		SUNDSTRAND	60% HAN		25 and 65 oC
FLURAN F-5500-1 NORTON IND.	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
FOAM MAT'L FROM ENVIRON CHAMBER	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
FREON MF	SOLVENT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
FREON MF	SOLVENT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
FREON TF	SOLVENT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
FREON TF	SOLVENT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
FRIGID-GO SYNTHETIC OIL SAE OW-20	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
FRIGID-GO SYNTHETIC OIL SAE OW-20	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
G321 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
GAFLEX	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
GALDEN D20	LUBRICANT	ROCKET RESEARCH	60.8% HAN	1:14	25 AND 65 oC
GOLD PLATED BERYLLIUM BRONZE	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
GOODYEAR COLLAPSIBLE TANK	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
GRAPHITAR GRADE 47	GRAPHITE	GENERAL ELECTRIC	LGP-1846		AMBIENT
GRAPHITAR GRADE 47	CERAMIC	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
GREASE 3451	LUBRICANT	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
GREEN/WHITE PAINTED MAT'L FROM CHAM	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
GRILON #BT-40	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
GROUP II METALS (Zn, Cd, Pb, Sn)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
GROUP II METALS (Zn,Cd,Pb,Sn, etc.)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
G-354 GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
HALOCARBON .8 OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
HALOCARBON .8 OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
HALOCARBON 1.8 OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
HALOCARBON 1.8 OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
HALOCARBON 6.3 OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
HALOCARBON 6.3 OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
HARD CHROME COATING ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
HARD CHROME COATING ON 17-4 PH	COATING	SUNDSTRAND	60% HAN		25 and 65 oC
HASTELLOYS	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
HAYNES ALLOY 25	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
HAYNES ALLOY 255	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
HAYNES ALLOY 718	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
HAYNES ALLOY 718	METAL	SUNDSTRAND	60% HAN		65 oC
HIGH STRENGTH POLYAMIDE #05-036	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
HIGH STRENGTH POLYAMIDE #05-059	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
HIMOD 550		GENERAL ELECTRIC	LGP-1846		AMBIENT
HIMOD 551		GENERAL ELECTRIC	LGP-1846		AMBIENT
HIMOD 552		GENERAL ELECTRIC	LGP-1846		AMBIENT
HI-T-LUBE COATING ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
HI-T-LUBE ON 17-4	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
HOSTALEN UHMW POLYMER	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
HOSTALEN UHMW POLYMER	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
HYDRAULIC 2105	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
HYDRAULIC 2105	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
HYPODERMIC NEEDLE	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
HYTREL #7246	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
HYTREL #7246	ELASTOMER	SUNDSTRAND	60% HAN		25 and 65 oC
INCO 718	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
ION-NITRIDED 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
IRON	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
JESSOP JS ALLOY 20 (UNS NO8020)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
JESSOP JS ALLOY 20 (UNS NO8020)	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
JESSOP JS ALLOY 276 (UNS 10276)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
JESSOP JS ALLOY 276 (UNS 10276)	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
JESSOP STEEL 20	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
JESSOP STEEL 276	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
JESSOP STEEL 276	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
KENDALL DEXRON II FLUID	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	2:2	AMBIENT
KENDALL DEXRON II FLUID	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
KENDEX 8895 FLUID		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
KENDEX 8895 FLUID		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
KENNAMETAL K602	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
KENNAMETAL K602	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
KENNAMETAL K701	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
KENNAMETAL K801	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
KENNAMETAL K801	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
KENNAMETAL K801	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
KENNAMETAL SPZ 313	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
KENSOL 48T		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
KENSOL 48T		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
KENSOL 48T FLUID	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
KENSOL 48T FLUID	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
KRATON-1650, ILC DOVER	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
KYNAR LINING	ELASTOMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
K-KARB	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
K-KARB	COATING	SUNDSTRAND	60% HAN		65 oC
K-RAMIC #SCA-1002 COATING	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
K-RAMIC #SCA-1002 COATING	COATING	SUNDSTRAND	60% HAN		25 and 65 oC
LCO-17 COATING ON 17-4	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
LC-1H COATING ON 17-4	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
LEXAN	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
LOCTITE 609	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
LOCTITE PRIMER N	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
LOCTITE #220		GENERAL ELECTRIC	LGP-1846		AMBIENT
LOCTITE #609		GENERAL ELECTRIC	LGP-1846		AMBIENT
LUCITE	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
LW-15 COATING ON 17-4	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
M2 TOOL STEEL (FULL SULFURIZED)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
M2 TOOL STEEL (PART SULFURIZED)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
[illegible] GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
MACHINIST'S LUBRICANT - PITTSFIELD	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
MACHINIST'S LUBRICANT - PITTSFIELD	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
MAGNAGOLD	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
MAGNAGOLD ON 17-4	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
MAGNALUBE G - GREASE	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
MATERIAL FROM FUME HOOD INTERIOR	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
METCO #309NS-3 COATING ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
METCO #350 ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
METCO #505 ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
METCO #605 NS W/UNDERCOAT (B50TF192	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
METCO #605NS		GENERAL ELECTRIC	LGP-1846		AMBIENT
METCO #74SF ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
METHYLENE BLUE	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
MG 120 SILVER SOLDER	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
MG 120 SILVER SOLDER 96/4% Sn-Ag	ALLOY	GENERAL ELECTRIC	LGP-1846		AMBIENT
MIL H 83282 B HYD. FLUID	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
MIL H 83282 B HYD. FLUID	HYDRAULIC FLUID	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
MILLATHANE E34, TSE-E-34-94,TSE IND	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
MOBAY TEXIN 355DR	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
MOBAY TEXIN 480 AR	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
MOBIL 1 5W-30	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
MOBIL 1 5W-30	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
MOBIL HFA	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
MOBIL HFA	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
MOBIL SHC 524	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
MOBIL SHC 524	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
MOBIL SHC 525	COATING	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
MOBIL SHC 525	COATING	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
MOBIL SHC 526	COATING	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
MOBIL SHC 526	COATING	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
MOLYDAG COATING ON 17-4	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
MOLYDAG ON 17-4 PH	LUBRICANT	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
MONSANTO GEOLAST 701-80	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
MoS2 COATING - EVERLUBE ON 17-4	LUBRICANT (DRY)	GENERAL ELECTRIC	LGP-1846		AMBIENT
MP35N STEEL	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
MP-355	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
MYKROY/MYCALEX 555/761	CERAMIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
NEDOX SF-2 COATING ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
NEODYNIUM-MAGNET	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
NEOPRENE, CODE J	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
NIBRON COATING ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
NICKEL	METAL	SUNDSTRAND	60% HAN		65 oC
NICKEL FLASH ON 17-4 PH	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
NICKEL FLASHED COATING ON 17-4PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
NITINOL WIRE	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
NITRIDED TRIBOCOR 532N	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
NITRIDED TRIBOCOR 532N	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
NITRILE ELASTOMER NBR-2	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
NITRILE ELASTOMER NBR-8	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
NITRILE ELASTOMER NBR-9	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
NITRILE OR BUNA-N #9214-700 (GREENE	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
NITRONIC 50	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
NITRONIC 50	METAL	SUNDSTRAND	60% HAN		65 oC
NITRONIC 60 (CRE)	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
Ni-RESIST GRADE C		GENERAL ELECTRIC	LGP-1846		AMBIENT

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
NORPRENE, NORTON IND.	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
NYLASINT #M4	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
NYLASINT #M4	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
NYLATRON GS - POPPET	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
NYLON 05-037	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
NYLON #05-037	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
OCEANIC HW 560		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
OCEANIC HW 560		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
O-RING ROD SEAL SHEFFER ACTUATOR	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
PACKED BORIDED 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
PAINT, TEMP. (1500 DEG. F) SENSING	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
PAINT, TEMP. (2500 DEG. F) SENSING	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
PAXON BA 50-100		GENERAL ELECTRIC	LGP-1846		AMBIENT
PAXON BA 50-100	POLYMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
PEBAX #2533 SN00	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
PEBAX #3533 SN00	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
PEBAX #4033 SN00	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
PEBAX #5533 SN00	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
PEBAX #6333 SN00	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
PENWALT KSL-213		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
PENWALT KSL-213		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
PENWALT KSL-550		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
PENWALT KSL-550		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
PENWALT SPINDLE OIL 4	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
PENWALT SPINDLE OIL 4	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
PERMALON-M LUBRICANT	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
PEURECO-DRAKEOL 10B LT MIN OIL NF	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
PEURECO-DRAKEOL 10B LT MIN OIL NF	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
PHOSPHONITRILIC FLUOROELASTOMER #92	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
PISTON FROM FS-925 FLOW SWITCH	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
POCO GRAPHITE #ACF-10QE2	CERAMIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
POCO GRAPHITE #ACF-10QE2	CERAMIC	SUNDSTRAND	60% HAN		25 and 65 oC
POLYAMIDE 05-036	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
POLYESTER URETHANE PU-1	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
POLYESTER URETHANE PU-2	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
POLYETHER URETHANE	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
POLYETHYLENE	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
POLYMER PE-100-A-027 ILC DOVER	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
POLYPROPYLENE	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
POLYVINYL CHLORIDE TUBING	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
POLYVINYLCHLORIDE TUBING	POLYMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
PRESSURE TRANSDUCER	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
PS-9242 SILICON CARBIDE	CERAMIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
PURE PETROLEUM BASE OIL-30 WEIGHT-A	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
RADIAN 1203-F60-R2	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
RADIAN VT-380	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
REEVES S/4616 (GUM)	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
REFLECTIVE TAPE FOR OPTRON	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
REXNORD DURALON BEARING MAT'L	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
RUBBER CR-1	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
RUBBER CR-2	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
RULON II	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
RULON II	POLYMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
RYNITE SST-35	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
RYNITE SST-35	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
RYNITE #530	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
RYNITE #530	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
SAE 50W MOTOR OIL	LUBRICANT	ROCKET RESEARCH	60.8% HAN	1:14	25 AND 65 oC
SANTOPRENE 101-64	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
SANTOPRENE 101-73	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
SANTOPRENE 201-55	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
SEAL FOR 6 IN. BORE CYLINDER	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
SERMATECH GC-WC-111 ON 17-4 PH	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
SERMATECH GG-wc-111 ON 17-4	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
SHELL 35 BASE OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
SHELL 35 BASE OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
SHELL 45 BASE OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
SHELL 45 BASE OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
SHELL 60 SPRAY BASE 69013	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
SHELL 60 SPRAY BASE 69013	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
SILICON CARBIDE	CERAMIC	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
SILICON CARBIDE PS-9242	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
SILICONE, CODE L	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
SILICONE RTV SEALANT	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
SILVER GOOP - NON SEIZING COMPOUND	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
SILVER PLATING ON 17-4	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
SLIP RING FROM SHEFFER ACTUATOR	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
STEEL 4140	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
STEEL 4340	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
STEEL MP35N	METAL	ROCKET RESEARCH	60.9% HAN	1:20	25 AND 65 oC
STELLITE	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
STELLITE #1016 WELD ROD	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
STELLITE #21 WELD ROD	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
STELLITE #21 WELD ROD	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
STELLITE #6 COATING ON 17-4PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
STELLITE #6 ON NICRALY ON 17-4	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
STELLITE #6 PLASMA SPRAYED (TTL)	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
STELLITE #6 PLASMA TRANSFER ARC	METAL COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
STELLITE #8 ON 17-4PH	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
STRATOFLEX 124-8 TEFLON HOSE	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
STRATOFLEX 124-8 TEFLON HOSE W/ CAR	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
SUNISCO 3GS FLUID	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
SUNISCO 3GS FLUID	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
SUPERPROLINE	ELASTOMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
SYNFLEX HOSE #3130-06	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
SYNTHETIC OIL 168 (NYE) 1:2	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
SYNTHETIC OIL 168 (NYE) 2:1	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
SYNTHETIC OIL 237A LOT U260 (NYE)	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
SYNTHETIC OIL 237A LOT U260 (NYE)	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
SYNTHETIC TORQUE OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
SYNTHETIC TORQUE OIL	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
TANTALUM	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
TANTALUM	METAL	SUNDSTRAND	60% HAN		25 and 65 oC
TANTALUM COATING	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
TANTALUM COATING	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
TEFLON 05-002	ELASTOMER	SUNDSTRAND	60% HAN		25 and 65 oC
TEFLON 05-026	ELASTOMER	SUNDSTRAND	60% HAN		25 and 65 oC
TEFLON 05-002	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
TEFLON 05-026	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
TEFLON 55450-3 (VIRGIN)	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
TEFLON 55450-3 (VIRGIN)	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
TEFZEL LINING	ELASTOMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
TEXACO AIRCRAFT OIL 15	LUBRICANT	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
TEXACO AIRCRAFT OIL 15	LUBRICANT	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
TIODIZE TIOLUBE 1175	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
TIODIZE TIOLUBE 1175	LUBRICANT	SUNDSTRAND	60% HAN		25 and 65 oC
TIODIZE TRIBO/COMP TDF		GENERAL ELECTRIC	LGP-1846		AMBIENT
TIOLUBE 660	LUBRICANT	GENERAL ELECTRIC	LGP-1846		AMBIENT
TITANIUM IMPLANTED WITH NITROGEN	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
TITANIUM NITRIDE COATING	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
TORLON 7130 - RETEST	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
TORLON 4275	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
TORLON 4275	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
TORLON 7130	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
TORLON 7130	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
TREAD 3130	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
TRIBALOY T-400 (BSOTF155) W/UNDERCO	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
TRIBALOY T-700		GENERAL ELECTRIC	LGP-1846		AMBIENT
TRIBALOY T-800 ON 17-4 PH	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
TRISTELLE ALLOY T5-2	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
TRISTELLE ALLOY TS-2	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
TUF-LOC PT-707 BEARING	COMPONENT	GENERAL ELECTRIC	LGP-1846		AMBIENT
TUNGSTEN CARBIDE (B50TF27) W/UNDERC	CERAMIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
TUNGSTEN WELD ROD	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
TUNGSTEN WELD ROD	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
TURCON 14	CLEANER	GENERAL ELECTRIC	LGP-1846		AMBIENT
TURCON 19	CLEANER	GENERAL ELECTRIC	LGP-1846		AMBIENT
TURCON 5	CLEANER	GENERAL ELECTRIC	LGP-1846		AMBIENT
TURCON 7	CLEANER	GENERAL ELECTRIC	LGP-1846		AMBIENT
TURCON 99	CLEANER	GENERAL ELECTRIC	LGP-1846		AMBIENT
UCAR LC-1H ON 17-4	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
UCAR LW-15 ON 17-4	COATING	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
UDEL P-1700	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
UDEL P-1700	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
ULTEM 4001	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
UNIROYAL BJLT M-40	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
UNIROYAL OZO-HA-0221	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
UNISAFE 40		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
UNISAFE 40		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
UNIVIS J13		GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
UNIVIS J13		GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
U/C NICRALY & TOPCOAT CHROME CARBID	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
U/C NICRALY & TOPCOAT STELLITE #6	COATING	GENERAL ELECTRIC	LGP-1846		AMBIENT
VASCO MATRIX I		GENERAL ELECTRIC	LGP-1846		AMBIENT
VASCO MATRIX II		GENERAL ELECTRIC	LGP-1846		AMBIENT
VASCOMAX C-250	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
VASCOMAX C-300	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
VASCOMAX C-350	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
VASCOMAX T-250	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
VASCOMAX T-300	METAL	GENERAL ELECTRIC	LGP-1846		AMBIENT
VESPEL #SP-1	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
VESPEL #SP-1	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
VESPEL #SP-21	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
VESPEL #SP-21	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT

Material Name	Material Type	Test Location	Propellant Type	Mixture Ratio	Test temperature
VESPEL #SP-210 15% GRAPHITE	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
VESPEL #SP-210 15% GRAPHITE	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
VESPEL #SP-211	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
VESPEL #SP-211	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
VESPEL #SP-211D156968	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
VESPEL #SP-211D156968	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
VESPEL #SP-22	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
VESPEL #SP-22	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
VICTREX 4800G	POLYMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
VICTREX 4800G	POLYMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
VICTREX GRADE 4101GL20	PLASTIC COMPOSITE	GENERAL ELECTRIC	LGP-1846		AMBIENT
VICTREX GR. 4101GL20	POLYMER	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
VIPLEX L-60	PLASTICIZER	GENERAL ELECTRIC	LGP-1846	1:2	AMBIENT
VIPLEX L-60	PLASTICIZER	GENERAL ELECTRIC	LGP-1846	2:1	AMBIENT
VITON	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
VITON, CODE T	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
VITON-1	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
VITON-2	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
WHITE BLADDER MAT'L	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
XNBR-2	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
XNBR-3	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
XNBR-6	ELASTOMER	US ARMY Ft. BELVOIR RDEC	LGP-1846		23 oC
YELLOW BLADDER MAT'L THICK	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
YELLOW BLADDER MAT'L THIN	ELASTOMER	GENERAL ELECTRIC	LGP-1846		AMBIENT
ZIRCONIUM ZR-702	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
ZIRCONIUM ZR-705	METAL	ROCKET RESEARCH	60.8% HAN		25 AND 65 oC
ZURCON 449	MISCELLANEOUS	GENERAL ELECTRIC	LGP-1846		AMBIENT
ZYTEL #101L	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
ZYTEL #101L	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC
ZYTEL #70643L	PLASTIC	GENERAL ELECTRIC	LGP-1846		AMBIENT
ZYTEL #70643L	PLASTIC	SUNDSTRAND	60% HAN		25 and 65 oC

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
10W-30 MOTOR OIL	720	30			COMPATIBLE	Mar 1990
111 GREASE	10748	448			COMPATIBLE	6-2-87
13-8 Mo PH					COMPATIBLE	6-2-87
13-8 Mo PH	2688	112			COMPATIBLE	6-2-87
15-5 PH	3912	163			COMPATIBLE	6-2-87
15-5 PH	720	30			INCOMPATIBLE	Mar 1990
17-4 PH	2688	112			COMPATIBLE	6-2-87
17-4 PH	16536	689			COMPATIBLE	6-2-87
17-4 PH	720	30			COMPATIBLE	Aug 1987
17-4 PH	16536	689			COMPATIBLE	6-2-87
17-4 PH COATED W/EVERLUBE 620C					COMPATIBLE	6-2-87
17-4 PH COATED W/EVERLUBE 620C	720	30			COMPATIBLE	Aug 1987
17-4 PH COATED W/HI-T-LUBE					COMPATIBLE	6-2-87
17-4 PH COATED W/HI-T-LUBE	720	30			INCOMPATIBLE	Aug 1987
17-4 PH COATED W/METCO 309N5-3					COMPATIBLE	6-2-87
17-4 PH COATED W/METCO 309N5-3	48	2			INCOMPATIBLE	Aug 1987
17-4 PH COATED W/METCO 505					COMPATIBLE	6-2-87
17-4 PH COATED W/METCO 505	720	30			COMPATIBLE	Aug 1987
17-4 PH COATED W/NEDOX SF-2					COMPATIBLE	6-2-87
17-4 PH COATED W/NEDOX SF-2	720	30			COMPATIBLE	Aug 1987
17-4 PH COATED W/NIBRONZE					COMPATIBLE	6-2-87
17-4 PH COATED W/NIBRONZE	720 and 24	30 and 1			INCOMPATIBLE	Aug 1987
17-7 PH	12792	533			COMPATIBLE	6-2-87
17-7 PH (MILL ANNNEALED)	720	30			COMPATIBLE	Mar 1990
33 GREASE			192	8	INCOMPATIBLE	6-2-87
3451 GREASE	10748	448			COMPATIBLE	6-2-87
4140 STEEL						
4140 STEEL, MODIFIED (TRIAL1)			4.5	0	INCOMPATIBLE	6-2-87
4140 STEEL, MODIFIED (TRIAL2)			4.5	0	INCOMPATIBLE	6-2-87
4335 STEEL			48	2	INCOMPATIBLE	6-2-87
4340 STEEL			24	1	INCOMPATIBLE	6-2-87
4340 STEEL						
70/30% Pt-Rh TC ALLOY (-)	7536	314			COMPATIBLE	6-2-87
74/26% W-Re TC ALLOY (-)	7536	314			COMPATIBLE	6-2-87
94/6% Pt-Rh TC ALLOY (+)	7536	314			COMPATIBLE	6-2-87
95/5% W-Re TC ALLOY (+)	7536	314			COMPATIBLE	6-2-87
AERO TEC LABS. ALT-644-30			168	7	INCOMPATIBLE	Dec 1988
AEROLON 1	4776	199			COMPATIBLE	6-2-87
AEROQUIP FC 300-12 AQP			408	17	INCOMPATIBLE	6-2-87
AEROQUIP HOSE TEFLON-SS	672	28			COMPATIBLE	6-2-87
AEROQUIP #AE246-6 HOSE	672	28			COMPATIBLE	6-2-87
AEROSHELL 7 GREASE	9024	376			COMPATIBLE	6-2-87
AEROSHELL 14 GREASE	720	30			INCOMPATIBLE	Mar 1990
AEROSHELL 17 GREASE	9024	376			COMPATIBLE	6-2-87
AEROSHELL 17 GREASE	720	30			INCOMPATIBLE	Mar 1990
AEROSHELL 22 GREASE	9024	376			COMPATIBLE	6-2-87
Ag PLATE ON 17-4 PH	720	30			INCOMPATIBLE	Mar 1990
Al BRONZE COATING ONLY (650TF161)			24	1	INCOMPATIBLE	6-2-87
Al BRONZE COATING (B50TF161) W/UNDE			24	1	INCOMPATIBLE	6-2-87
ALCRYN R1101 B70 THP-3	1680	70			COMPATIBLE	Dec 1988
ALCRYN R1201 B70A THP-1	1680	70			COMPATIBLE	Dec 1988
ALT 644-30 BLADDER MATERIAL			432	18	INCOMPATIBLE	6-2-87
ALUMINUM, SOFT						
ALUMINUM ALLOYS, SOFT					INCOMPATIBLE	6-2-87

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
ALUMINUM Al-356	72	3			COMPATIBLE	6-2-87
Al-6061	2736	114			COMPATIBLE	6-2-87
Al-6061	720	30			INCOMPATIBLE	Mar 1990
Al-7075					COMPATIBLE	6-2-87
Al-7075	720 and 144	30 and 6	144	6	INCOMPATIBLE	Aug 1987
AMAX MAGNESIUM			48	2	INCOMPATIBLE	6-2-87
ARLON 1160	9696	404			COMPATIBLE	6-2-87
ARLON 1160	720	30			INCOMPATIBLE	Mar 1990
ARLON 1260	9696	404			COMPATIBLE	6-2-87
ARLON 1260	720	30			COMPATIBLE	Mar 1990
BALSTON FILTER #050-05-BX	12792	533			COMPATIBLE	6-2-87
BALSTON FILTER #050-05-BH	12792	533			COMPATIBLE	6-2-87
BALSTON FILTER #050-05-BQ	12792	533			COMPATIBLE	6-2-87
BALSTON FILTER #050-05-CH	15624	651			COMPATIBLE	6-2-87
BALSTON FILTER #050-05-CQ			1512	63	INCOMPATIBLE	6-2-87
BEACON 325 GREASE			5040	210	INCOMPATIBLE	6-2-87
BERYLLIUM BRONZE SILVER PLATED VALV	48	2			COMPATIBLE	6-2-87
BLUE RECORDING INK	3912	163			COMPATIBLE	6-2-87
BRASS (PROJECTILE)			216	9	INCOMPATIBLE	6-2-87
BRAYCO 783E MICRONIC	720	30			INCOMPATIBLE	Mar 1990
BRAYCO 726	2736	114			COMPATIBLE	6-2-87
BRAYCO 726	2736	114			COMPATIBLE	6-2-87
BRAYCO 756	1800	75			COMPATIBLE	6-2-87
BRAYCO 756	1800	75			COMPATIBLE	6-2-87
BRAYCO 783E	1800	75			COMPATIBLE	6-2-87
BRAYCO 783E	1800	75			COMPATIBLE	6-2-87
BRAYCO 864	2736	114			COMPATIBLE	6-2-87
BRAYCO 864	2736	114			COMPATIBLE	6-2-87
BRAYCO MICRONIC 762 FLUID	6720	280			COMPATIBLE	6-2-87
BRAYCO MICRONIC 762 FLUID	6720	280			COMPATIBLE	6-2-87
BRAYCO MICRONIC 882 FLUID			2064	86	INCOMPATIBLE	6-2-87
BRAYCO MICRONIC 882 FLUID			2064	86	INCOMPATIBLE	6-2-87
BREAK-FREE	672	28			COMPATIBLE	6-2-87
BREAK-FREE	672	28			COMPATIBLE	6-2-87
BUNA-N CODE P	4776	199			COMPATIBLE	6-2-87
BUTYL 3Q86 CODE C	4776	199			COMPATIBLE	6-2-87
C100 GREASE	10820	451			COMPATIBLE	6-2-87
CARBON BEARING	720	30			INCOMPATIBLE	Mar 1990
CERAMIC MAGNET (TEMPSONICS)	5472	228			COMPATIBLE	6-2-87
CERAMIC MAGNET - CC12 (ORANGE RES.)	4776	199			COMPATIBLE	6-2-87
CERAMIC THRUST WASHER	720	30			INCOMPATIBLE	Mar 1990
CHROMIUM	720	30			COMPATIBLE	Aug 1987
CONFORMA CLAD WC 300 COATING			24	1	INCOMPATIBLE	6-2-87
COPPER	216	9			INCOMPATIBLE	Aug 1987
COPPER ALLOYS					INCOMPATIBLE	6-2-87
COPPER ALLOYS						
COPPER SHAVINGS			216	9	INCOMPATIBLE	6-2-87
CrB2 COATING ON 17-4 PH	11924	497			COMPATIBLE	6-2-87
CrB2 COATING ON 17-4 PH	720 and 336	30 and 14	336	14	INCOMPATIBLE	Aug 1987
CRES-301	720	30			COMPATIBLE	Mar 1990
CRES-301	12792	533			COMPATIBLE	6-2-87
CRES-302	5424	226			COMPATIBLE	6-2-87
CRES-302	720	30			COMPATIBLE	Mar 1990
CRES-303	14496	604			COMPATIBLE	6-2-87
CRES-303	720 and 48	30 and 2	48	2	INCOMPATIBLE	Aug 1987

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
CRES-304					COMPATIBLE	6-2-87
CRES-304	720	30			COMPATIBLE	Mar 1990
CRES-304	12792	533			COMPATIBLE	6-2-87
CRES-308	5424	226			COMPATIBLE	6-2-87
CRES-308	720	30			COMPATIBLE	Mar 1990
CRES-316	2496	104			COMPATIBLE	6-2-87
CRES-316	5472	228			COMPATIBLE	6-2-87
CRES-316					COMPATIBLE	6-2-87
CRES-316	720	30			COMPATIBLE	Mar 1990
CRES-316	720 and 288	30 and 12			INCOMPATIBLE	Aug 1987
CRES-416						
CRES-416					INCOMPATIBLE	6-2-87
CRES-440C						
CRES-44C					INCOMPATIBLE	6-2-87
CRES-454 CUSTOM			3360	140	INCOMPATIBLE	6-2-87
DELRIN 100ST			2208	92	INCOMPATIBLE	6-2-87
DELRIN 500			672	28	INCOMPATIBLE	6-2-87
DELRIN 500T			1512	63	INCOMPATIBLE	6-2-87
DELRIN ACETAL			1540	64	INCOMPATIBLE	6-2-87
DELRIN (ACETAL BASE)			2016	84	INCOMPATIBLE	6-2-87
DISOGRIN CD-9250			168	7	INCOMPATIBLE	Dec 1988
DISOGRIN COMPOUND 6865-RING			576	24	INCOMPATIBLE	6-2-87
DISOGRIN COMPOUND 9250			360	15	INCOMPATIBLE	6-2-87
DISOGRIN COMPOUND 9250-RING			576	24	INCOMPATIBLE	6-2-87
DOW CORNING 200 FLUID, 10.0 CS	8160	340			COMPATIBLE	6-2-87
DOW CORNING 200 FLUID, 10.0 CS	8160	340			COMPATIBLE	6-2-87
DOW CORNING 200 FLUID, 1.0 CS	8160	340			COMPATIBLE	6-2-87
DOW CORNING 200 FLUID, 1.0 CS	8160	340			COMPATIBLE	6-2-87
DOW CORNING 200 FLUID, 2.0 CS	8160	340			COMPATIBLE	6-2-87
DOW CORNING 200 FLUID, 2.0 CS	8160	340			COMPATIBLE	6-2-87
DOW CORNING 200 FLUID, 5.0 CS	8160	340			COMPATIBLE	6-2-87
DOW CORNING 200 FLUID, 5.0 CS	8160	340			COMPATIBLE	6-2-87
DOW CORNING SILICONE SEALANT	840	35			COMPATIBLE	6-2-87
DOW CORNING #33 GREASE					COMPATIBLE	6-2-87
DO-ALL BLUE "STEEL INK" LAYOUT DYE	12792	533			COMPATIBLE	6-2-87
EDPM, CODE H			2424	101	INCOMPATIBLE	6-2-87
EMERY 2943-D FRIGID-GO HYDR. FLUID	8160	340			COMPATIBLE	6-2-87
EMERY 2943-D FRIGID-GO HYDR. FLUID	8160	340			COMPATIBLE	6-2-87
EMERY 2946-A SYNTHETIC HYD. FLUID			3504	146	INCOMPATIBLE	6-2-87
EMERY 2946-A SYNTHETIC HYD. FLUID			3504	146	INCOMPATIBLE	6-2-87
ENERPAC HYDRAULIC OIL	11924	497			COMPATIBLE	6-2-87
ENERPAC HYDRAULIC OIL	11924	497			COMPATIBLE	6-2-87
ENERPAC HYDRAULIC OIL	11924	497			COMPATIBLE	6-2-87
EOPZY PRIMER (ZINC CHROMATE), PC			360	15	INCOMPATIBLE	6-2-87
EPOXY ENAMEL PAINT, PC-BRAND-PEN-RU	2904	121			COMPATIBLE	6-2-87
EPOXY ENAMEL PAINT, PC-BRAND-PEP-1	2904	121			COMPATIBLE	6-2-87
EPR REEVES 4594 (GUM)	1680	70			COMPATIBLE	Dec 1988
EPR REEVES 4601 (GUM)	1680	70			COMPATIBLE	Dec 1988
ERIFON 818 FLUID	6744	281			COMPATIBLE	6-2-87
ERIFON 818 FLUID	6744	281			COMPATIBLE	6-2-87
ETHYLENE PROPYLENE (1ST SOURCE)			96	4	INCOMPATIBLE	6-2-87
ETHYLENE PROPYLENE (2ND SOURCE)	5472	228			COMPATIBLE	6-2-87
ETHYLENE PROPYLENE - EPDM #9214-801	2904	121			COMPATIBLE	6-2-87
ETHYLENE PROPYLENE - EPR #9214-952	2904	121			COMPATIBLE	6-2-87
EVERLUBE 620C ON 17-4 PH			696	29	INCOMPATIBLE	6-2-87

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
FERRALIUM ALLOY 255			2016	84	INCOMPATIBLE	6-2-87
FERRALIUM ALLOY 255	720	30			COMPATIBLE	Mar 1990
FERRALIUM ALLOY 255 (RETEST)	11108	463			COMPATIBLE	6-2-87
FLOOR 1	1416	59			COMPATIBLE	6-2-87
FLOOR 2	1416	59			COMPATIBLE	6-2-87
FLUORINERT FC-40	6744	281			COMPATIBLE	6-2-87
FLUORINERT FC-40	6744	281			COMPATIBLE	6-2-87
FLUORINERT FC-75	6864	286			COMPATIBLE	6-2-87
FLUORINERT FC-75	6864	286			COMPATIBLE	6-2-87
FLUORINERT FC-84	6744	281			COMPATIBLE	6-2-87
FLUORINERT FC-84	6744	281			COMPATIBLE	6-2-87
FLUORINERT ELECTRONIC LIQUID FC-77	8328	347			COMPATIBLE	6-2-87
FLUORINERT ELECTRONIC LIQUID FC-77	8328	347			COMPATIBLE	6-2-87
FLUOROCARBON PEEK	12764	532			COMPATIBLE	6-2-87
FLUOROCARBON PEEK	720	30			COMPATIBLE	Aug 1987
FLUOROCARBON RUBBER - VITON #9214-7	2904	121			COMPATIBLE	6-2-87
FLUOROCARBON RUBBER-VITON #9214-731	2904	121			COMPATIBLE	6-2-87
FLUOROCARBON - 33	12764	532			COMPATIBLE	6-2-87
FLUOROCARBON - 33	720 and 288	30 and 12	288	12	INCOMPATIBLE	Aug 1987
FLURAN F-5500-1 NORTON IND.	1680	70			COMPATIBLE	Dec 1988
FOAM MAT'L FROM ENVIRON CHAMBER			24	1	INCOMPATIBLE	6-2-87
FREON MF	1752	73			COMPATIBLE	6-2-87
FREON MF	1752	73			COMPATIBLE	6-2-87
FREON TF	8160	340			COMPATIBLE	6-2-87
FREON TF	8328	347			COMPATIBLE	6-2-87
FRIGID-GO SYNTHETIC OIL SAE OW-20	8160	340			COMPATIBLE	6-2-87
FRIGID-GO SYNTHETIC OIL SAE OW-20	8160	340			COMPATIBLE	6-2-87
G321 GREASE			6024	251	INCOMPATIBLE	6-2-87
GAFLEX	1680	70			COMPATIBLE	Dec 1988
GALDEN D20	720	30			COMPATIBLE	Mar 1990
GOLD PLATED BERYLLIUM BRONZE			336	14	INCOMPATIBLE	6-2-87
GOODYEAR COLLAPSIBLE TANK	1680	70			COMPATIBLE	Dec 1988
GRAPHITAR GRADE 47	11108	463			COMPATIBLE	6-2-87
GRAPHITAR GRADE 47	720	30			COMPATIBLE	Mar 1990
GREASE 3451	720	30			COMPATIBLE	Mar 1990
GREEN/WHITE PAINTED MAT'L FROM CHAM			24	1	INCOMPATIBLE	6-2-87
GRILON #BT-40	14496	604			COMPATIBLE	6-2-87
GROUP II METALS (Zn, Cd, Pb, Sn)					INCOMPATIBLE	6-2-87
GROUP II METALS (Zn,Cd,Pb,Sn, etc.)						
G-354 GREASE	7536	314			COMPATIBLE	6-2-87
HALOCARBON .8 OIL	6864	286			COMPATIBLE	6-2-87
HALOCARBON .8 OIL	6864	286			COMPATIBLE	6-2-87
HALOCARBON 1.8 OIL	6744	281			COMPATIBLE	6-2-87
HALOCARBON 1.8 OIL	6744	281			COMPATIBLE	6-2-87
HALOCARBON 6.3 OIL	6744	281			COMPATIBLE	6-2-87
HALOCARBON 6.3 OIL	6744	281			COMPATIBLE	6-2-87
HARD CHROME COATING ON 17-4 PH	11924	497			COMPATIBLE	6-2-87
HARD CHROME COATING ON 17-4 PH	720	30			COMPATIBLE	Aug 1987
HASTELLOYS					COMPATIBLE	6-2-87
HAYNES ALLOY 25	11108	463			COMPATIBLE	6-2-87
HAYNES ALLOY 255	720	30			COMPATIBLE	Mar 1990
HAYNES ALLOY 718	11108	463			COMPATIBLE	6-2-87
HAYNES ALLOY 718	720	30			COMPATIBLE	Aug 1987
HIGH STRENGTH POLYAMIDE #05-036	16536	689			COMPATIBLE	6-2-87
HIGH STRENGTH POLYAMIDE #05-059	16536	689			COMPATIBLE	6-2-87

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
HIMOD 550	4776	199			COMPATIBLE	6-2-87
HIMOD 551	4776	199			COMPATIBLE	6-2-87
HIMOD 552	4776	199			COMPATIBLE	6-2-87
HI-T-LUBE COATING ON 17-4 PH			744	31	INCOMPATIBLE	6-2-87
HI-T-LUBE ON 17-4	9192	383			COMPATIBLE	6-2-87
HOSTALEN UHMW POLYMER	11108	463			COMPATIBLE	6-2-87
HOSTALEN UHMW POLYMER	720	30			COMPATIBLE	Aug 1987
HYDRAULIC 2105	6744	281			COMPATIBLE	6-2-87
HYDRAULIC 2105	6744	281			COMPATIBLE	6-2-87
HYPODERMIC NEEDLE	4104	171			COMPATIBLE	6-2-87
HYTREL #7246	14496	604			COMPATIBLE	6-2-87
HYTREL #7246	720	30			COMPATIBLE	Aug 1987
INCO 718	2688	112			COMPATIBLE	6-2-87
ION-NITRIDED 17-4 PH			3264	136	INCOMPATIBLE	6-2-87
IRON			216	9	INCOMPATIBLE	Aug 1987
JESSOP JS ALLOY 20 (UNS NO8020)	14496	604			COMPATIBLE	6-2-87
JESSOP JS ALLOY 20 (UNS NO8020)	720	30			COMPATIBLE	Aug 1987
JESSOP JS ALLOY 276 (UNS 10276)	14496	604			COMPATIBLE	6-2-87
JESSOP JS ALLOY 276 (UNS 10276)	720	30			COMPATIBLE	Aug 1987
JESSOP STEEL 20	2496	104			COMPATIBLE	6-2-87
JESSOP STEEL 276	2496	104			COMPATIBLE	6-2-87
JESSOP STEEL 276	12764	532			COMPATIBLE	6-2-87
KENDALL DEXRON II FLUID	7536	314			COMPATIBLE	6-2-87
KENDALL DEXRON II FLUID	7536	314			COMPATIBLE	6-2-87
KENDEX 8895 FLUID			2832	118	INCOMPATIBLE	6-2-87
KENDEX 8895 FLUID			2832	118	INCOMPATIBLE	6-2-87
KENNAMETAL K602	11924	497			COMPATIBLE	6-2-87
KENNAMETAL K602	720	30			COMPATIBLE	Aug 1987
KENNAMETAL K701			696	29	INCOMPATIBLE	6-2-87
KENNAMETAL K801		0			COMPATIBLE	6-2-87
KENNAMETAL K801			7128	297	INCOMPATIBLE	6-2-87
KENNAMETAL K801	729 and 360	30 and 15	36	15	INCOMPATIBLE	Aug 1987
KENNAMETAL SPZ 313			24	1	INCOMPATIBLE	6-2-87
KENSOL 48T	2736	114			COMPATIBLE	6-2-87
KENSOL 48T	2736	114			COMPATIBLE	6-2-87
KENSOL 48T FLUID	7536	314			COMPATIBLE	6-2-87
KENSOL 48T FLUID	7536	314			COMPATIBLE	6-2-87
KRATON-1650, ILC DOVER	1680	70			COMPATIBLE	Dec 1988
KYNAR LINING	720	30			COMPATIBLE	1990
K-KARB	11108	463			COMPATIBLE	[illegible]
K-KARB	720	30			COMPATIBLE	Aug 1987
K-RAMIC #SCA-1002 COATING	15696	654			COMPATIBLE	6-2-87
K-RAMIC #SCA-1002 COATING	720 and 96	30 and 4	96	4	INCOMPATIBLE	Aug 1987
LCO-17 COATING ON 17-4			4008	167	INCOMPATIBLE	6-2-87
LC-1H COATING ON 17-4	8664	361			COMPATIBLE	6-2-87
LEXAN					COMPATIBLE	6-2-87
LOCTITE 609	720	30			COMPATIBLE	6-2-87
LOCTITE PRIMER N	13224	551			COMPATIBLE	6-2-87
LOCTITE #220			5064	211	INCOMPATIBLE	6-2-87
LOCTITE #609	13224	551			COMPATIBLE	6-2-87
LUCITE					COMPATIBLE	6-2-87
LW-15 COATING ON 17-4	8664	361			COMPATIBLE	6-2-87
M2 TOOL STEEL (FULL SULFURIZED)			72	3	INCOMPATIBLE	6-2-87
M2 TOOL STEEL (PART SULFURIZED)			72	3	INCOMPATIBLE	6-2-87

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
MACHINIST'S LUBRICANT - PITTSFIELD	2640	110			COMPATIBLE	6-2-87
MACHINIST'S LUBRICANT - PITTSFIELD	2640	110			COMPATIBLE	6-2-87
MAGNAGOLD					COMPATIBLE	6-2-87
MAGNAGOLD ON 17-4			4536	189	INCOMPATIBLE	6-2-87
MAGNALUBE G - GREASE	6744	281			COMPATIBLE	6-2-87
MATERIAL FROM FUME HOOD INTERIOR	12792	533			COMPATIBLE	6-2-87
METCO #309NS-3 COATING ON 17-4 PH			24	1	INCOMPATIBLE	6-2-87
METCO #350 ON 17-4 PH			24	1	INCOMPATIBLE	6-2-87
METCO #505 ON 17-4 PH			24	1	INCOMPATIBLE	6-2-87
METCO #605 NS W/UNDERCOAT (B50TF192			24	1	INCOMPATIBLE	6-2-87
METCO #605NS			24	1	INCOMPATIBLE	6-2-87
METCO #74SF ON 17-4 PH			48	2	INCOMPATIBLE	6-2-87
METHYLENE BLUE	864	36			COMPATIBLE	6-2-87
MG 120 SILVER SOLDER	720	30			INCOMPATIBLE	Mar 1990
MG 120 SILVER SOLDER 96/4% Sn-Ag	3288	137			COMPATIBLE	6-2-87
MIL E 83282 B HYD. FLUID			2088	87	INCOMPATIBLE	6-2-87
MIL H 83282 B HYD. FLUID			2088	87	INCOMPATIBLE	6-2-87
MILLATHANE E34, TSE-E-34-94,TSE IND	1680	70			COMPATIBLE	Dec 1988
MOBAY TEXIN 355DR			168	7	INCOMPATIBLE	Dec 1988
MOBAY TEXIN 480 AR			168	7	INCOMPATIBLE	Dec 1988
MOBIL 1 5W-30	4104	171			COMPATIBLE	6-2-87
MOBIL 1 5W-30	4104	171			COMPATIBLE	6-2-87
MOBIL HFA	1800	75			COMPATIBLE	6-2-87
MOBIL HFA	1800	75			COMPATIBLE	6-2-87
MOBIL SHC 524	4104	171			COMPATIBLE	6-2-87
MOBIL SHC 524	4104	171			COMPATIBLE	6-2-87
MOBIL SHC 525	4104	171			COMPATIBLE	6-2-87
MOBIL SHC 525	4104	171			COMPATIBLE	6-2-87
MOBIL SHC 526	4104	171			COMPATIBLE	6-2-87
MOBIL SHC 526	4014	167			COMPATIBLE	6-2-87
MOLYDAG COATING ON 17-4	8496	354			COMPATIBLE	6-2-87
MOLYDAG ON 17-4 PH	720	30			INCOMPATIBLE	Mar 1990
MONSANTO GEOLAST 701-80	1680	70			COMPATIBLE	Dec 1988
MoS2 COATING - EVERLUBE ON 17-4			1540	64	INCOMPATIBLE	6-2-87
MP35N STEEL	1416	59			COMPATIBLE	6-2-87
MP-355	2688	112			COMPATIBLE	6-2-87
MYKROY/MYCALEX 555/761			384	16	INCOMPATIBLE	6-2-87
NEDOX SF-2 COATING ON 17-4 PH			24	1	INCOMPATIBLE	6-2-87
NEODYNIUM-MAGNET	840	35			COMPATIBLE	6-2-87
NEOPRENE, CODE J			144	6	INCOMPATIBLE	6-2-87
NIBRON COATING ON 17-4 PH			96	4	INCOMPATIBLE	6-2-87
NICKEL	720	30			COMPATIBLE	Aug 1987
NICKEL FLASH ON 17-4 PH	720	30			INCOMPATIBLE	Mar 1990
NICKEL FLASHED COATING ON 17-4PH	3288	137			COMPATIBLE	6-2-87
NITINOL WIRE	6192	258			COMPATIBLE	6-2-87
NITRIDED TRIBOCOR 532N	8496	354			COMPATIBLE	6-2-87
NITRIDED TRIBOCOR 532N	720	30			COMPATIBLE	Mar 1990
NITRILE ELASTOMER NBR-2	1680	70			COMPATIBLE	Dec 1988
NITRILE ELASTOMER NBR-8	1680	70			COMPATIBLE	Dec 1988
NITRILE ELASTOMER NBR-9	1680	70			COMPATIBLE	Dec 1988
NITRILE OR BUNA-N #9214-700 (GREENE	2904	121			COMPATIBLE	6-2-87
NITRONIC 50	11108	463			COMPATIBLE	6-2-87
NITRONIC 50	720	30			COMPATIBLE	Aug 1987
NITRONIC 60 (CRE)					COMPATIBLE	6-2-87
Ni-RESIST GRADE C			24	1	INCOMPATIBLE	6-2-87

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
NORPRENE, NORTON IND.	1680	70			COMPATIBLE	Dec 1988
NYLASINT #M4	14496	604			COMPATIBLE	6-2-87
NYLASINT #M4	720 and 144	30 and 6	144	6	INCOMPATIBLE	Aug 1987
NYLATRON GS - POPPET	6192	258			COMPATIBLE	6-2-87
NYLON 05-037	720	30			COMPATIBLE	Aug 1987
NYLON #05-037	16536	689			COMPATIBLE	6-2-87
OCEANIC HW 560			2088	87	INCOMPATIBLE	6-2-87
OCEANIC HW 560			2088	87	INCOMPATIBLE	6-2-87
O-RING ROD SEAL SHEFFER ACTUATOR	11108	463			COMPATIBLE	6-2-87
PACKED BORIDED 17-4 PH			1176	49	INCOMPATIBLE	6-2-87
PAINT, TEMP. (1500 DEG. F) SENSING	2904	121			COMPATIBLE	6-2-87
PAINT, TEMP. (2500 DEG. F) SENSING	2904	121			COMPATIBLE	6-2-87
PAXON BA 50-100	9360	390			COMPATIBLE	6-2-87
PAXON BA 50-100	720	30			COMPATIBLE	Mar 1990
PEBAX #2533 SN00			192	8	INCOMPATIBLE	6-2-87
PEBAX #3533 SN00			192	8	INCOMPATIBLE	6-2-87
PEBAX #4033 SN00			192	8	INCOMPATIBLE	6-2-87
PEBAX #5533 SN00			192	8	INCOMPATIBLE	6-2-87
PEBAX #6333 SN00			192	8	INCOMPATIBLE	6-2-87
PENWALT KSL-213			2088	87	INCOMPATIBLE	6-2-87
PENWALT KSL-213			2088	87	INCOMPATIBLE	6-2-87
PENWALT KSL-550			2088	87	INCOMPATIBLE	6-2-87
PENWALT KSL-550			2088	87	INCOMPATIBLE	6-2-87
PENWALT SPINDLE OIL 4			2088	87	INCOMPATIBLE	6-2-87
PENWALT SPINDLE OIL 4			2088	67	INCOMPATIBLE	6-2-87
PERMALON-M LUBRICANT	1	24			COMPATIBLE	6-2-87
PEURECO-DRAKEOL 10B LT MIN OIL NF	8328	347			COMPATIBLE	6-2-87
PEURECO-DRAKEOL 10B LT MIN OIL NF	8328	347			COMPATIBLE	6-2-87
PHOSPHONITRILIC FLUOROELASTOMER #92	2904	121			COMPATIBLE	6-2-87
PISTON FROM FS-925 FLOW SWITCH	11924	497			COMPATIBLE	6-2-87
POCO GRAPHITE #ACF-10QE2	16536	689			COMPATIBLE	6-2-87
POCO GRAPHITE #ACF-10QE2	720	30			INCOMPATIBLE	Aug 1987
POLYAMIDE 05-036	720	30			COMPATIBLE	Aug 1987
POLYESTER URETHANE PU-1	1008	42			INCOMPATIBLE	Dec 1988
POLYESTER URETHANE PU-2	1008	42			INCOMPATIBLE	Dec 1988
POLYETHER URETHANE			288	12	INCOMPATIBLE	6-2-87
POLYETHYLENE					COMPATIBLE	6-2-87
POLYMER PE-100-A-027 ILC DOVER	1680	70			COMPATIBLE	Dec 1988
POLYPROPYLENE					COMPATIBLE	6-2-87
POLYVINYL CHLORIDE TUBING	6192	258			COMPATIBLE	6-2-87
POLYVINYLCHLORIDE TUBING	720	30			COMPATIBLE	Mar 1990
PRESSURE TRANSDUCER			864	36	INCOMPATIBLE	6-2-87
PS-9242 SILICON CARBIDE	9696	404			COMPATIBLE	6-2-87
PURE PETROLEUM BASE OIL-30 WEIGHT-A			2568	107	INCOMPATIBLE	6-2-87
RADIAN 1203-F60-R2	1680	70			COMPATIBLE	Dec 1988
RADIAN VT-380	1680	70			COMPATIBLE	Dec 1988
REEVES S/4616 (GUM)	1680	70			COMPATIBLE	Dec 1988
REFLECTIVE TAPE FOR OPTRON	3288	137			COMPATIBLE	6-2-87
REXNORD DURALON BEARING MAT'L	12792	533			COMPATIBLE	6-2-87
RUBBER CR-1	1680	70			COMPATIBLE	Dec 1988
RUBBER CR-2	1680	70			COMPATIBLE	Dec 1988
RULON II	8688	362			COMPATIBLE	6-2-87
RULON II	720	30			COMPATIBLE	Mar 1990
RYNITE SST-35	11108	463			COMPATIBLE	6-2-87

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
RYNITE #530	14496	604			COMPATIBLE	6-2-87
RYNITE #530	720	30			COMPATIBLE	Aug 1987
SAE 50W MOTOR OIL	720	30			COMPATIBLE	Mar 1990
SANTOPRENE 101-64	1680	70			COMPATIBLE	Dec 1988
SANTOPRENE 101-73	1680	70			COMPATIBLE	Dec 1988
SANTOPRENE 201-55	1680	70			COMPATIBLE	Dec 1988
SEAL FOR 6 IN. BORE CYLINDER	9696	404			COMPATIBLE	6-2-87
SERMATECH GC-WC-111 ON 17-4 PH	720	30			INCOMPATIBLE	Mar 1990
SERMATECH GG-wc-111 ON 17-4	6864	286			COMPATIBLE	6-2-87
SHELL 35 BASE OIL	7536	314			COMPATIBLE	6-2-87
SHELL 35 BASE OIL	7536	314			COMPATIBLE	6-2-87
SHELL 45 BASE OIL			2832	118	INCOMPATIBLE	6-2-87
SHELL 45 BASE OIL			2832	118	INCOMPATIBLE	6-2-87
SHELL 60 SPRAY BASE 69013	7536	314			COMPATIBLE	6-2-87
SHELL 60 SPRAY BASE 69013	7536	314			COMPATIBLE	6-2-87
SILICON CARBIDE	720	30			COMPATIBLE	Mar 1990
SILICON CARBIDE PS-9242	720	30			COMPATIBLE	Mar 1990
SILICONE, CODE L	4776	199			COMPATIBLE	6-2-87
SILICONE RTV SEALANT	3912	163			COMPATIBLE	6-2-87
SILVER GOOP - NON SEIZING COMPOUND	2904	121			COMPATIBLE	6-2-87
SILVER PLATING ON 17-4	8160	340			COMPATIBLE	6-2-87
SLIP RING FROM SHEFFER ACTUATOR	11108	463			COMPATIBLE	6-2-87
STEEL 4140					INCOMPATIBLE	6-2-87
STEEL 4340					INCOMPATIBLE	6-2-87
STEEL MP35N	720	30			COMPATIBLE	Mar 1990
STELLITE					COMPATIBLE	6-2-87
STELLITE #1016 WELD ROD	12764	532			COMPATIBLE	6-2-87
STELLITE #21 WELD ROD	12764	532			COMPATIBLE	6-2-87
STELLITE #21 WELD ROD	720	30			COMPATIBLE	Aug 1987
STELLITE #6 COATING ON 17-4PH	10580	441			COMPATIBLE	6-2-87
STELLITE #6 ON NICRALY ON 17-4	720	30			COMPATIBLE	Mar 1990
STELLITE #6 PLASMA SPRAYED (TTL)			192	8	INCOMPATIBLE	6-2-87
STELLITE #6 PLASMA TRANSFER ARC	10152	423			COMPATIBLE	6-2-87
STELLITE #8 ON 17-4PH	720	30			COMPATIBLE	Mar 1990
STRATOFLEX 124-8 TEFLON HOSE	8496	354			COMPATIBLE	6-2-87
STRATOFLEX 124-8 TEFLON HOSE W/ CAR			3840	160	INCOMPATIBLE	6-2-87
SUNISCO 3GS FLUID	7536	314			COMPATIBLE	6-2-87
SUNISCO 3GS FLUID	7536	314			COMPATIBLE	6-2-87
SUPERPROLINE	720	30			COMPATIBLE	Mar 1990
SYNFLEX HOSE #3130-06			672	28	INCOMPATIBLE	6-2-87
SYNTHETIC OIL 168 (NYE) 1:2			3504	146	INCOMPATIBLE	6-2-87
SYNTHETIC OIL 168 (NYE) 2:1			3504	146	INCOMPATIBLE	6-2-87
SYNTHETIC OIL 237A LOT U260 (NYE)			3504	146	INCOMPATIBLE	6-2-87
SYNTHETIC OIL 237A LOT U260 (NYE)			3504	146	INCOMPATIBLE	6-2-87
SYNTHETIC TORQUE OIL	4104	171			COMPATIBLE	6-2-87
SYNTHETIC TORQUE OIL	4104	171			COMPATIBLE	6-2-87
TANTALUM	432	18			COMPATIBLE	6-2-87
TANTALUM	720	30			COMPATIBLE	Aug 1987
TANTALUM COATING	6336	264			COMPATIBLE	6-2-87
TANTALUM COATING	720	30			COMPATIBLE	Mar 1990
TEFLON 05-002	720	30			COMPATIBLE	Aug 1987
TEFLON 05-026	720	30			COMPATIBLE	Aug 1987
TEFLON 05-002	16536	689			COMPATIBLE	6-2-87
TEFLON 05-026	16536	689			COMPATIBLE	6-2-87
TEFLON 55450-3 (VIRGIN)	12792	533			COMPATIBLE	6-2-87

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
TEFLON 55450-3 (VIRGIN)	720	30			COMPATIBLE	Aug 1987
TEFZEL LINING	720	30			COMPATIBLE	Mar 1990
TEXACO AIRCRAFT OIL 15	1800	75			COMPATIBLE	6-2-87
TEXACO AIRCRAFT OIL 15	1800	75			COMPATIBLE	6-2-87
TIODIZE TIOLUBE 1175	11924	497			COMPATIBLE	6-2-87
TIODIZE TIOLUBE 1175	720	30			COMPATIBLE	Aug 1987
TIODIZE TRIBO/COMP TDF	11108	463			COMPATIBLE	6-2-87
TIOLUBE 660			696	29	INCOMPATIBLE	6-2-87
TITANIUM IMPLANTED WITH NITROGEN	432	18			COMPATIBLE	6-2-87
TITANIUM NITRIDE COATING	432	18			COMPATIBLE	6-2-87
TORLON 7130 - RETEST	10580	441			COMPATIBLE	6-2-87
TORLON 4275	14496	604			COMPATIBLE	6-2-87
TORLON 4275	720	30			COMPATIBLE	Aug 1987
TORLON 7130	15696	654			COMPATIBLE	6-2-87
TORLON 7130	720	30			COMPATIBLE	Aug 1987
TREAD 3130	1680	70			COMPATIBLE	Dec 1988
TRIBALOY T-400 (BSOTF155) W/UNDERCO			384	16	INCOMPATIBLE	6-2-87
TRIBALOY T-700			840	35	INCOMPATIBLE	6-2-87
TRIBALOY T-800 ON 17-4 PH			24	1	INCOMPATIBLE	6-2-87
TRISTELLE ALLOY T5-2	720	30			COMPATIBLE	Mar 1990
TRISTELLE ALLOY TS-2	10820	451			COMPATIBLE	6-2-87
TUF-LOC PT-707 BEARING	11108	463			COMPATIBLE	6-2-87
TUNGSTEN CARBIDE (B50TF27) W/UNDERC			3192	133	INCOMPATIBLE	6-2-87
TUNGSTEN WELD ROD	5424	226			COMPATIBLE	6-2-87
TUNGSTEN WELD ROD	720	30			INCOMPATIBLE	Mar 1990
TURCON 14	4776	199			COMPATIBLE	6-2-87
TURCON 19	4776	199			COMPATIBLE	6-2-87
TURCON 5	4776	199			COMPATIBLE	6-2-87
TURCON 7	4776	199			COMPATIBLE	6-2-87
TURCON 99	4776	199			COMPATIBLE	6-2-87
UCAR LC-1H ON 17-4	720	30			INCOMPATIBLE	Mar 1990
UCAR LW-15 ON 17-4	720	30			INCOMPATIBLE	Mar 1990
UDEL P-1700	14496	604			COMPATIBLE	6-2-87
UDEL P-1700	720	30			COMPATIBLE	Aug 1987
ULTEM 4001	14496	604			COMPATIBLE	6-2-87
UNIROYAL BJLT M-40	1680	70			COMPATIBLE	Dec 1988
UNIROYAL OZO-HA-0221	1680	70			COMPATIBLE	Dec 1988
UNISAFE 40			2088	87	INCOMPATIBLE	6-2-87
UNISAFE 40			2088	87	INCOMPATIBLE	6-2-87
UNIVIS J13	1800	75			COMPATIBLE	6-2-87
UNIVIS J13	1800	75			COMPATIBLE	6-2-87
U/C NICRALY & TOPCOAT CHROME CARBID			360	15	INCOMPATIBLE	6-2-87
U/C NICRALY & TOPCOAT STELLITE #6	10580	441			COMPATIBLE	6-2-87
VASCO MATRIX I			24	1	INCOMPATIBLE	6-2-87
VASCO MATRIX II			24	1	INCOMPATIBLE	6-2-87
VASCOMAX C-250			24	1	INCOMPATIBLE	6-2-87
VASCOMAX C-300			24	1	INCOMPATIBLE	6-2-87
VASCOMAX C-350			24	1	INCOMPATIBLE	6-2-87
VASCOMAX T-250			24	1	INCOMPATIBLE	6-2-87
VASCOMAX T-300			48	2	INCOMPATIBLE	6-2-87
VESPEL #SP-1	14496	604			COMPATIBLE	6-2-87
VESPEL #SP-1	720	30			COMPATIBLE	Aug 1987
VESPEL #SP-21	14496	604			COMPATIBLE	6-2-87
VESPEL #SP-21	15696	654			COMPATIBLE	6-2-87
VESPEL #SP-21	720	30			COMPATIBLE	Aug 1987

Material Name	Hours Exposure to Date	Days Exposure to Date	Hours to Failure	Days to Failure	Compatibility Rating	Update (date)
VESPEL #SP-210 15% GRAPHITE	15696	654			COMPATIBLE	6-2-87
VESPEL #SP-210 15% GRAPHITE	720	30			COMPATIBLE	Aug 1987
VESPEL #SP-211	14496	604			COMPATIBLE	6-2-87
VESPEL #SP-211	720	30			COMPATIBLE	Aug 1987
VESPEL #SP-211D156968	15696	654			COMPATIBLE	6-2-87
VESPEL #SP-211D156968	720	30			COMPATIBLE	Aug 1987
VESPEL #SP-22	14496	604			COMPATIBLE	6-2-87
VESPEL #SP-22	720	30			COMPATIBLE	Aug 1987
VICTREX 4800G	10748	448			COMPATIBLE	6-2-87
VICTREX 4800G	720	30			COMPATIBLE	Mar 1990
VICTREX GRADE 4101GL20	10748	448			COMPATIBLE	6-2-87
VICTREX GR. 4101GL20	720	30			COMPATIBLE	Mar 1990
VIPLEX L-60	4104	171			COMPATIBLE	6-2-87
VIPLEX L-60	4104	171			COMPATIBLE	6-2-87
VITON					COMPATIBLE	6-2-87
VITON, CODE T	4776	199			COMPATIBLE	6-2-87
VITON-1	1680	70			COMPATIBLE	Dec 1988
VITON-2	1680	70			COMPATIBLE	Dec 1988
WHITE BLADDER MAT'L			3864	161	INCOMPATIBLE	6-2-87
XNBR-2	1680	70			COMPATIBLE	Dec 1988
XNBR-3	1680	70			COMPATIBLE	Dec 1988
XNBR-6	1680	70			COMPATIBLE	Dec 1988
YELLOW BLADDER MAT'L THICK			3864	161	INCOMPATIBLE	6-2-87
YELLOW BLADDER MAT'L THIN			3864	161	INCOMPATIBLE	6-2-87
ZIRCONIUM ZR-702	720	30			COMPATIBLE	Mar 1990
ZIRCONIUM ZR-705	720	30			COMPATIBLE	Mar 1990
ZURCON 449	4776	199			COMPATIBLE	6-2-87
ZYTEL #101L	14496	604			COMPATIBLE	6-2-87
ZYTEL #101L	720	30			COMPATIBLE	Aug 1987
ZYTEL #70643L	14496	604			COMPATIBLE	6-2-87
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